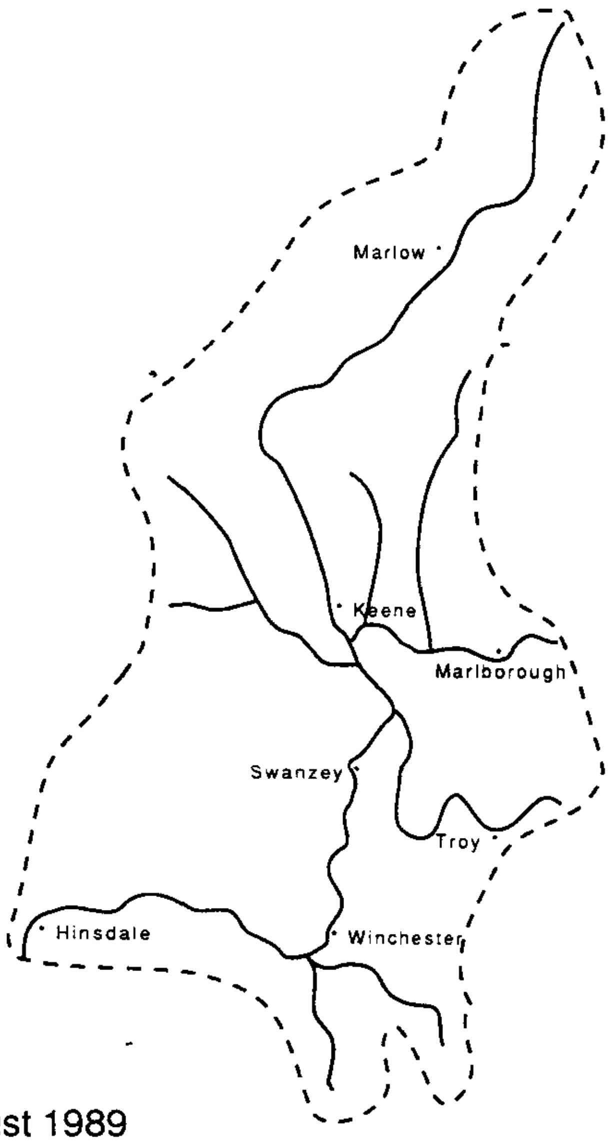
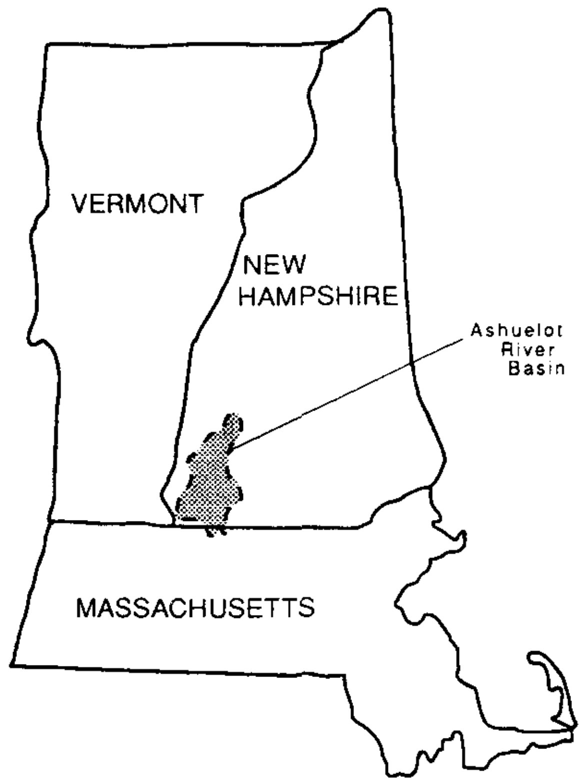
General Investigation
Ashuelot River Basin

Water Resources Study





August 1989

US Army Corps of Engineers
New England Division

WATER RESOURCES STUDY
ASHUELOT RIVER BASIN
NEW HAMPSHIRE

GENERAL INVESTIGATION

August 1989

Department of Army
New England Division, Corps of Engineers
424 Trapelo Road
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EXECUTIVE SUMMARY

This report documents the results of a water resources study conducted in the Ashuelot River Basin in southwest New Hampshire. In accordance with the study authority, the study has reviewed several potential water resources problems which could impact the economic vitality of the basin. Examination of these problems has led to the determination that economic losses sustained from flood events pose a significant concern.

Although four flood control projects have previously been constructed within the watershed, floods experienced in 1984 and 1987 have disrupted normal transportation patterns, inundated roadways, parking lots and driveways and damaged structures and inventories at basement and first floor levels. Flood damages have mostly occurred in the City of Keene, New Hampshire, the economic center of the watershed. To a lesser extent, however, two other communities, Marlborough and Winchester, New Hampshire, have also experienced flood damages from these flood events.

Within these communities, flood damage reduction alternatives were formulated and evaluated to determine economic feasibility. These alternatives included consideration of a flood control reservoir, bypass channels, local protection projects with earthen dikes and concrete walls, channel modifications and nonstructural flood protection measures. Attention was also given to environmental and social impacts, engineering feasibility and public acceptability of the flood damage reduction alternatives.

Results of the analysis of structural and nonstructural alternatives have indicated that the only alternative found to be economically feasible was a channel modification project in the community of Marlborough, New Hampshire. The total cost of this project is estimated at $80,500 with a corresponding benefit cost ratio of 1.3. Due to the relatively small magnitude of cost associated with this project, Corps participation under the General Investigation program has not been recommended. However, there is a continuing authority program, Section 205 of the Flood Control Act of 1948, available to the community that could be utilized to further investigate this improvement if the community so desired.

The investigation perceives that flood damages in and downstream of the flood plains will be more severe in the future. This concern is particularly acute in the flood plain located in southern Keene, where the most significant economic and population growth is occurring. Unless higher standards for more restrictive or comprehensive flood plain management regulations are adopted by this community, continued construction encroachment in the flood plain will significantly reduce the natural flood plain storage function.

This investigation has determined that flood damage reduction alternatives are not currently economically justified except for one location where project costs are of such low magnitude that continued participation under the General Investigation Program is not appropriate. This report responds to the Congressional resolutions adopted 26 September 1984.

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SECTION I - INTRODUCTION

STUDY AUTHORITY

The Ashuelot River Water Resources Study was authorized by a Resolution of the Senate Committee on the Environment and Public Works, adopted 26 September 1984, which states:

> That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the reports on the Connecticut River, Massachusetts, New Hampshire, Vermont, and Connecticut, published as House Document Numbered 455, Seventy-fifth Congress, Second Session, and other pertinent reports, with a view to determining the advisability of modifying the existing project at this time, with particular reference to providing improvements for flood damage reduction and other allied purposes in the Ashuelot River Sub-Basin, New Hampshire."

PURPOSE AND SCOPE

This report provides an evaluation of the water resources problems and needs, considers the views of local interests and examines alternatives available to meet those needs, for the Ashuelot River Basin in southwest New Hampshire. Structural and nonstructural solutions, benefit and cost criteria, and Federal interest towards implementing alternative measures have been evaluated and includes consideration of potential impacts on identified environmental resources within the study area. In accordance with the study authority, the investigation was confined to the Ashuelot River Basin, a sub-basin of the Connecticut River.

PLANNING OBJECTIVE

This study was undertaken to examine the water resources problems and needs of the Ashuelot River Basin, New Hampshire. Potential alternatives were formulated including a cost benefit analysis to meet the areas needs. This report provides a definition of problems, description of alternative plans of improvement and evaluations of technical, economic environmental and social affects of the plans. This information provides the basis for implementation considerations associated with each plan by others.

REPORT AND STUDY PROCESS

This study provides a mechanism to accommodate non-Federal participation in contributing to an efficient and effective planning process. The investigation is a preliminary indication of the potential solutions which could be recommended to the Congress as a Federal project. The investigation provides the basis for determining the merits of continuing the study.

The planning process incorporates four planning functions, problem identification, formulation of alternatives, impact assessment and evaluation. The problem identification task identifies the water resources problems and establishes study planning objectives. The formulation of alternatives develops both structural and nonstructural methods to respond to the identified problems. The impact assessment examines the existing social, economic and environmental conditions. The evaluation compares the relative values of each alternative plan towards achieving the study objectives and determines whether there is Federal interest in continuing the study.

Upon review and approval by the Board of Engineers for Rivers and Harbors, the final report of the Chief of Engineers will be forwarded to the Secretary of the Army, the Office of Management and Budget, and ultimately transmitted to Congress for their information.

PRIOR PROJECTS AND STUDIES

A review of prior projects and studies within the Ashuelot River Basin has been performed. A description of these projects and studies are summarized below:

Surry Mountain Lake Project:

Authorized by Congress in June 1936, this flood control reservoir is a unit of a coordinated system of reservoirs for flood control in the Connecticut River Basin. The dam is located on the main stem of the Ashuelot River about 34 miles above the confluence with the Connecticut River and 5 miles north of Keene. The drainage area above the dam is 100 square miles and the storage capacity at the spillway crest is 33,000 acre-feet. Construction was started during August, 1939 and completed in October, 1941.

Local Flood Protection Project - Main Stem of Ashuelot River:

Authorized by the Chief of Engineers through Section 2 of the Flood Control Act of 1937, this project improved flow conditions in the reach of the Ashuelot River most critical to the operation of Surry Mountain Dam and Reservoir. The project also provided additional flood reduction in southern Keene, New Hampshire. The project consisted of snagging and clearing of channel debris and excavating two cutoff channels. The project is located in in the City of Keene and in the town of Swanzey. Construction was started in June, 1954 and completed in August, 1954.

Otter Brook Lake Project:

Authorized by Congress in September, 1954, this flood control reservoir provides flood protection to Keene, N.H., and to downstream communities along the Connecticut River. The dam is located on Otter Brook, 2.4 miles upstream from its junction with the Branch, a tributary of the Ashuelot River. The drainage area above the dam is 47.2 square miles and the cumulative capacity at the spillway crest is 18,320 acre feet. Construction was started during September, 1956 and completed in August, 1958.

Beaver Brook Project:

Authorized under the special continuing authority of Section 205 of the 1948 Flood Control Act, this project consists of channel improvements in the lower reaches of Beaver Brook in Keene, and a modified outlet structure in the mid-reach of the Brook (Three Mile Swamp). The purpose of this project is principally to provide additional flood protection in eastern Keene. Construction was started during October, 1985 and completed in June, 1986.

Honey Hill Project:

This Corps of Engineers proposal was originally authorized on 18 August 1941. However, it was never constructed and was deauthorized in August, 1971. The dam would be located on the South Branch of the Ashuelot River in the town of West Swanzey, about 5.6 miles upstream of the confluence with the Ashuelot River. This project was designed as a multi-purpose project for flood control and recreation.

Nonstructural Flood Damage Reduction Study - Keene, N.H.:

This flood damage mitigation study for Keene was completed in May, 1980. It was based on Section 73 of Public Law 93-251. This study readdressed the well established recurring flood problem of the City of Keene, which is located in a flat valley at the foot of several steep tributaries. The overall objective of this study was to prepare a comprehensive flood plain management plan. The recommended plan consisted of a combination of structural and nonstructural flood damage reduction measures. Portions of the recommended plan were adopted and led to, for instance, the Beaver Brook Project previously noted. Other portions of the recommended plan such as protecting flood plain storage from construction encroachment have not been adopted.

SECTION II
EXISTING CONDITIONS AND NATURAL RESOURCES

PHYSICAL RESOURCES

General Setting

The Ashuelot River Basin is located in the southwest corner of New Hampshire in Sullivan and Cheshire Counties, with a small portion extending into Franklin County, Massachusetts as shown in Plate 1. The watershed has a diamond-elliptical shape with a length of 42 miles and a width of 17 miles. The basin has a total drainage area of 421 square miles and is part of the Connecticut River Basin. The river has a length of 64 miles.

Area Profile

The City of Keene is the central economic center of the basin. Original settlers were attracted by the agricultural lands of the flood plain in southern Keene. While these early settlements were primarily agricultural, the towns' location on the highway from Concord, New Hampshire, to Brattleboro, Vermont, encouraged growth of shops and services for travellers as well as grist mills serving Keene residents.

Industrial activities had become important to the City of Keene by the early 19th century. The Ashuelot River and its tributaries provided power to attract many mills. These mills engaged in a variety of activities ranging from finishing and weaving cloth to forges, iron foundries and woodworking mills in South Keene. In the 20th century, industrial activities in the Keene area have continued to grow with an increased emphasis on the production of intermediate goods such as machinery used in other industrial processes.

The economy of the area ranges from an industrialized landscape centered in the City of Keene to the more predominant rural and sparsely populated communities of the watershed. Manufacturing in the City includes precision ball bearings, machine tools, furniture, textiles, optical goods, business forms, toys jewelry and machinary. Other economic activities such as professional services and commerce in Keene have also grown in modern times. Most agricultural activity is devoted to dairy farming and apple production.

Currently, economic growth has imposed considerable demand for development of the remaining flood plain lands in the central portion of the basin and in particular, the Keene area. The growth in population of Keene and other townships in Cheshire County for the period between 1970 and 1980 is shown in Table 1. Keene has remained as the most populated of all communities and accounts for slightly more than one-third the population of Cheshire County. In addition, the population within Cheshire County has increased about 20 percent during the period between 1970 and 1980.

TABLE 1

POPULATION CHARACTERISTICS

Location	Population (1980)	Population (1970)	Population Change
Winchester Town	3,465	2,799	666
Hindsdale Town	3,631	3,276	355
Swanzey Town	5,183	4,162	1,021
Keene City	21,449	20,467	982
Cheshire County	62,116	52,364	9,752

Regional Geology

Southwestern New Hampshire and the Ashuelot River Basin have had a complex geologic history. During early to middle Paleozoic time, shallow seas repeatedly inundated the area and deposited a thick sequence of silts, sands and limey muds. In middle Paleozoic time, molten rock intruded the lower layers of these sediments and solidified as the gray-green granite now known as the Oliverian plutonic series. Information on the geology of the basin is illustrated on Plate 2. Between middle and late Paleozoic time the sediment, now rock, was squeezed into folds, faulted and metamorphosed. Another sequence of molten rock was squeezed into this folded and faulted rock and solidified as the pink granites of the present New Hampshire plutonic series. Elsewhere in New Hampshire, after the late Palezoic, still more molten rock intruded into the crust and some of the molten rock erupted in volcanic activity. The igneous rocks formed the White Mountain plutonic-volcanic series named after the high mountains underlain by these rocks. Following the crustal building there began a long period of erosion alternating or coinciding with periods of general uplift. During the uplifts rivers cut broad valleys into the bedrock and in the latest uplift period many rivers cut down below the floors of their older broad valleys. Within much more recent geological time, the climate became colder and snows began to stay year round in the higher valleys. With the net accumulation of snow year to year, the buried snow turned to ice and began flowing downhill as glaciers. Meanwhile a great continental ice sheet began building in Canada and started moving southward. The great ice sheet coalesced with the mountain valley glaciers and the combined snow fields thickened eventually covering every mountain and valley in New Hampshire.

Broken and weathered bedrock and residual soils became entrained in the glacial ice and were redeposited as till. There were several advancing pulses of the ice sheet, but eventually the climate warmed back to near its present state and the ice sheet began wasting away from the lower elevations and latitudes and meltwater from the glaciers replaced ice as the dominant geological force. As the ice melted it left behind the entrained materials as till but the meltwater started redistributing some of this material in water laid deposits. In some places the meltwater became dammed by masses of wasting ice or by sediment deposits and temporary glacial lakes formed which sometimes suddenly disappeared as the damming materials became breached.

The Ashuelot River, for the most part, is in the Central Highlands physiographic region which, in the Ashuelot Basin, consists of low mountains and hills and a stretch of a broad valley around the Keene area. Just before emptying into the Connecticut River, the river cuts into the Connecticut Valley physiographic province which at Hinsdale is around eight miles wide.

The underlying type of bedrock and its structural grain generally influence the course of the Ashuelot River. The river rises near the western flank of the Cardigan Pluton, a large granite body which underlies the highlands of west central New Hampshire. The river then flows in a general southwesterly direction across a less resistant meta-sedimentary and meta-volcanic rock sequence. In Surry, the river encounters the more resistant granitic rocks of the Swanzey dome and bends towards the south-southeast apparently picking up the structural grain of this feature and a fault zone to the south. Near Winchester, N.H. the river again heads westward running around the south flank of the Ashuelot Pluton of the resistant Kinsman quartz monzonite on its way to the Connecticut River.

The upper one-third of the valley is narrow and floored by till. Most of the lower two-thirds of the valley is wider and floored by stratified gravels, sands, silts and some clays. The valley widens out into a basin in the Keene-Swanzey area. Varved silts and clays occur in the foundation soils of the Surry Mountain Dam as well as in south Keene where the clay in these deposits was once exploited for brickmaking. The varved deposits indicate a still-water depositional environment, probably an old glacial meltwater lake bottom formed either by a local natural dam composed of glacial debris or ice, or backup from the Connecticut River glacial lake. Waters entering the glacial lake dropped their sediments and formed the stratified sand and gravel deposits in these valleys. The City of Keene is built on the basin formed by these level stratified deposits which are about 2.5 miles wide at this point. The basin continues to the Swanzey-Richmond town line, but the main stem of the Ashuelot and its flat valley bend westward through Winchester where another flat floored tributary valley joins from the south. The valley alluvium becomes coarser south of Keene with sand and gravel prevailing over silt. West of Winchester the valley narrows and cuts through till for the next three miles after which it cuts rapidly down through the gravel terraces of the Connecticut Valley reaching the Connecticut River in the broad valley at Hinsdale.

Seismicity

Based primarily on historical seismicity, the Ashuelot River Basin is in a relatively stable zone. The nearest seismically active areas with historic earthquakes of Modified Mercalli (MM) intensities greater than VII are at Ossipee, New Hampshire, Cape Ann, Massachusetts, and Moodus, Connecticut. The maximum earthquake intensity from an earthquake originating locally is MMI VI while that expected from an earthquake from one of the above mentioned seismically active zones could produce an earthquake of MM Intensity VI-VII in the Ashuelot River Basin.

Topography

The topography of the Ashuelot River Basin is hilly and primarily forested with elevations ranging above mean sea level from Mt. Monadnock (3165 feet) to the confluence with the Connecticut River near Hinsdale (200 feet). Elevations in the project areas range from 800 feet at Marlborough to 440 feet at Winchester. In its entire course, the Ashuelot River falls 1473 feet of which 240 feet are in the last six miles. The terrain in the upper watershed is steep and conducive to rapid runoff. However, the Keene flood plain located in the central section of the watershed is a large flat flood water retention area.

Climatology

The mean annual precipitation over the watershed is approximately 40 inches, distributed uniformly throughout the year. Average monthly precipitation records at Keene vary from a maximum of 11.09 inches in July, 1915, to a minimum of 0.20 inches in September, 1964. Monthly precipitation records for Keene are listed in Table 2.

The average annual atmospheric temperature at Keene is about 46 degrees Fahrenheit. Average monthly temperatures vary widely throughout the year from 21 degrees in January to 70 degrees in July. Extremes in temperature range from a low of minus 32 degrees in January and February to a high of 104 degrees in July. Table 3 lists the mean, maximum, and minimum monthly temperatures at Keene.

The mean annual snowfall at Keene is 63 inches with 52 percent of this occurring in the months of January and February. The variation of the average monthly snowfall is shown in Table 4. Snow surveys have been taken in the basin by the Corps of Engineers since December, 1948. Water content in the snow cover reaches a maximum during March. From 1948 to 1980, water content has averaged about 5.2 inches, with a maximum of 9.4 and a minimum of 1.0 inch.

TABLE 2

PRECIPITATION AT KEENE, NEW HAMPSHIRE
(89 YEARS OF RECORD - 1891 THROUGH 1980)

Month	Mean (inches)	Maximum (inches)	Minimum (inches)
January	2.96	9.24	0.76
February	2.62	7.04	0.57
March	3.22	7.60	0.40
April	3.15	6.65	0.35
May	3.35	7.02	0.79
June	3.46	7.73	0.41
July	3.72	11.09	1.07
August	3.62	8.96	1.05
September	3.53	10.39	0.20
October	2.84	7.84	0.23
November	3.33	7.67	0.52
December	3.16	8.86	0.51
Annual	38.94	52.72	27.12

TABLE 3

ATMOSPHERIC TEMPERATURES AT KEENE, NEW HAMPSHIRE
(88 YEARS OF RECORD - 1891 THROUGH 1980)

Month	Mean (Degrees-F)	Maximum (Degrees-F)	Minimum (Degrees-F)
January	21.3	66	-32
February	22.5	65	-32
March	32.9	85	-21
April	44.6	91	1
May	58.0	95	21
June	64.7	98	27
July	69.5	104	34
August	67.3	102	27
September	60.0	101	19
October	49.3	90	10
November	37.7	80	-15
December	25.5	64	-29
Annual	45.8	-	-

TABLE 4

MONTHLY SNOWFALL AT KEENE, NEW HAMPSHIRE
(88 YEARS OF RECORD - 1892 THROUGH 1980)

Month	Mean	Percent of Annual
January	16.4	25.5
February	16.3	25.4
March	11.4	17.9
April	3.2	4.9
May	-	-
June	-	-
July	-	-
August	-	-
September	-	-
October	0.1	0.1
November	3.7	5.7
December	13.2	20.5
Annual	5.2	100.0

Hydrography

The Ashuelot River has its source at May Pond in Pillsbury State Park located in Washington, New Hampshire. A watershed map of the Ashuelot River Basin is shown in Plate 1 and a profile of the River and its major tributaries are shown in Plate 18. The river flows in a southwesterly direction through several small ponds and enters Surry Mountain Lake, a Corps of Engineers flood control reservoir. Between May Pond and Surry Mountain lake, the river has a fall of 1100 feet. This fall occurs in a river length of 30 miles for an average slope of 37 feet per mile. From Surry Mountain Dam, the river continues in a southerly direction passing over Faulkner and Colony Dam in the City of Keene. At this point, the river enters what is referred to as the Keene flood plain. This natural flood plain extends 8.6 miles downstream to the West Swanzey Dam and falls 6 feet for an average slope of 0.8 feet per mile. The river continues from the West Swanzey Dam to the town of Winchester with a gradual slope. At Winchester, the river turns westward and drops rapidly entering the Connecticut River at Hinsdale.

The most predominant hydrographic feature of the Ashuelot River Basin is the flood plain in Keene which is located in the near center of the basin. About 75 percent of the drainage area empties into this reach of river which is the principal flood damage area in the Ashuelot River Basin. This reach of river is generally considered to lie between the Faulkner and Colony Dam in Keene and the Dickenson Dam in West Swanzey. Three large tributaries feed the main stem of the Ashuelot River in the Keene flood plain. The meandering river channel has a low discharge capacity due to the flat gradient, with the result that floodwaters cause considerable depth of pondage.

Numerous tributaries feed the main stem of the river. In the upper portions of the watershed, relatively small tributaries including Grassy Brook, Dart Brook and Thompson Brook feed the main stem at somewhat regularly spaced intervals. In the near center of the watershed, three large tributaries, The Branch River, Ash Swamp Brook and South Branch River, feed the main stem within a tightly spaced configuration. In the lower portions of the watershed, relatively intermediate sized tributaries including Wheelock Brook, Mirey Brook and Broad Brook feed the main stem at somewhat regularly spaced intervals. The drainage areas in the Ashuelot River Basin are shown in Table 5.

The largest of the tributaries is The Branch River. The Branch River is formed at the confluence of Minnewawa Brook and Otter Brook in Keene. The river flows 2.5 miles west where it enters the Ashuelot River and the Keene flood plain. Major sub-tributaries within The Branch include Otter Brook, the Minnewawa Brook and Beaver Brook.

Otter Brook has its source in Cedar Pond in Stoddard, New Hampshire. The brook flows in a southwesterly direction where it enters Otter Brook Lake, a Corps of Engineers flood control reservoir. From Otter Brook Lake, the brook flows 2.5 miles south where it meets Minnewawa Brook to form the Branch River. Minnewawa Brook has its source at the Howe Reservoir/Silver Lake area in Harrisville, New Hampshire, on the western mountainous slopes of the Ashuelot River Basin. The brook flows in a westerly direction through the Town of

Marlborough, New Hampshire, until it meets Otter Brook. Beaver Brook flows southward through the City of Keene and joins the Branch River in the Keene flood plain. Although Beaver Brook has a total fall of over 700 feet in 8 miles of length, the lower 2 miles and that portion in the vicinity of Three Mile Swamp are relatively flat.

Ash Swamp Brook is formed at the confluence of the Dickinson and Black Brooks in Keene. The brook flows in a southeasterly direction where it enters the Ashuelot River in the Keene flood plain. The total drainage area of the Brook is 18 square miles and has a total fall of 40 feet in a length of 3 miles for an average slope of 13 feet per mile.

The South Branch has its source in the Town of Troy, New Hampshire. The drainage area of the South Branch includes the western slope of Mount Monadnock in the southeastern corner of the Ashuelot River Basin. The South Branch enters the Ashuelot River in the southern portion of the Keene flood plain between the City of Keene and West Swanzey. The river has a total length of 12 miles and a fall of 500 feet for an average slope of 42 feet per mile.

There are three main stem Ashuelot River USGS gaging stations. One is located upstream of Surry Mountain Lake at Gilsum, another directly downstream of Surry Mountain Lake at Gilsum, and the third, at the mouth of the river at Hinsdale. In addition, tributary streamflow has been recorded along Otter Brook and the South Branch Ashuelot at Webb, New Hampshire. Mean, maximum and minimum monthly flows for the Ashuelot River at Gilsum and Hinsdale are shown in Table 6.

TABLE 5

DRAINAGE AREAS IN THE ASHUELOT RIVER BASIN

Location	Drainage Area (square miles)
Main Stem Ashuelot River	
Mouth..................................	421
USGS Gage at Hinsdale..................	420
West Swanzey Dam	310
Above confluence of the South Branch....	236
South City Limit Keene, N.H............	215
Above confluence of the Branch River....	114
Faulkner and Colony Dam................	110
USGS Gage below Surry Mountain Dam......	101
Surry Mountain Dam.....................	100
USGS Gage at Gilsum, N.H.	71
South Branch of the Ashuelot River	
Mouth..................................	72
USGS Gage at Webb, N.H.................	36
Ash Swamp Brook at Mouth....................	18
The Branch River at Mouth...................	100
Beaver Brook at Mouth.......................	10
Otter Brook	
Mouth..................................	55
USGS Gage at Otter Brook Dam............	47
Minnewawa Brook at Mouth....................	33

TABLE 6

MONTHLY STREAMFLOW ASHUELOT RIVER

	Gilsum DA = 71.1 sq mi (1922 through 1980)			Hinsdale DA = 420 sq mi (1907 through 1985)		
	Mean (cfs)	Max (cfs)	Min (cfs)	Mean (cfs)	Max (cfs)	Min (cfs)
January	106	247	14.0	595	1,539	84
February	87	253	12.0	603	2,016	113
March	213	803	29.0	1,242	4,392	273
April	421	833	124.0	1,915	3,723	693
May	193	464	53.0	1,009	2,175	341
June	84	251	9.6	528	2,075	97
July	41	208	4.4	280	1,182	61
August	29	140	3.2	206	1,032	51
September	41	443	2.7	241	2,394	59
October	61	358	3.7	314	1,474	49
November	118	425	6.7	554	2,248	55
December	121	424	16.0	638	1,727	113
Annual	126	191	40.0	675	1,093	216

ENVIRONMENTAL SETTING

The Study Area consists of a diverse and productive ecosystem characterized by a mixture of Northern Hardwoods (Beech, Birch, Maple, Hemlock) and freshwater wetland communities which provide important habitat to many species of fish and wildlife.

The study area is designated as Northern Hardwood forest community. The dominant forest vegetation includes sugar maple (Acer saccharum), yellow birch (Betula alleghaniensis), beech (Fagus grandifolia) and eastern hemlock (Tsuga canadensis). Other components of the broad-leaf deciduous forest include red, striped and mountain maple (Acer rubrum, A. pensylvanicum, A. spicatum), white ash (Fraxinus americana), mountain laurel (Kalmia latifolia), white pine (Pinus strobus), black cherry (Prunus serotina), American yew (Taxus canadensis), basswood (Tilia americana), and elm (Ulmus americana).

A wetland classification scheme as described by Cowardin et al. 1979 divides wetlands into five systems. These systems are further divided into subsystems, classes, sub-classes, and dominance types. Of interest in the Ashuelot River Basin is the Palustrine System; all non-tidal wetlands dominated by trees, shrubs, and persistent emergent herbaceous plants. Four types of palustrine wetlands are found in the basin; open water/aquatic bed, emergent, scrub/shrub and forested.

The open water/aquatic bed wetlands are shallow areas displaying mosaic patterns of open water and stands of rooted floating aquatic plants which grow at or below the water surface. Some small areas of exclusively open water wetland are also present. Emergent wetlands have non-woody vegetation which grows above the water surface. Scrub/shrub wetlands consist of areas of hydrophytic shrubs and smaller trees up to 20 feet in height. Forested wetlands are primarily pole stage stands of primarily red maple.

Species of birds typical of mixed deciduous uplands that would be expected to occur year-round along the Ashuelot River include woodpeckers (hairy, downy, and flickers), tufted titmouse, black-capped chickadee, brown creeper, mockingbird, bluejay, crow, cedar waxwing, American goldfinch, white-throated sparrow, northern junco, song sparrow, ring-necked pheasant, and ruffed grouse. Woodland species common during the summer (breeding) season may include a number of flycatchers, wrens, thrushes, vireos, and numerous wood warblers. In addition, a variety of spring and fall migrants would be excepted to pass through the area. Species such as red-headed woodpecker, Carolina wren, gray-cheeked thrush, ruby-crowned kinglet, white-eyed vireo, Philadelphia vireo, and warblers would be expected to occur as transients. Winter residents of the hardwood forest would be expected to include northern shrike, pine grosbeak, tree sparrow, snow bunting, and snowy owls.

Mallard, black and wood ducks and a number of wading birds would likely be found using the riparian and palustrine wetlands in the project area. Great blue heron, black-crowned night heron and belted kingfisher would be expected to be present during much of the year. In addition, a number of raptors would be expected to frequent the area including osprey, American kestrel, northern harrier, red-tailed and red-shouldered hawks and several species of owls.

Fish species reported as occurring in the Ashuelot River include rainbow smelt (Osmerus mordax), brook trout (Salvelinus fonitanals), brown and rainbow trout (Salmo trutta and S. gairdneri), white sucker (Catostomus commersoni), chubsucker (Erimyzon oblongus), blacknose and longnose dace (Rhinichthys atratulus and R. cataractae), fallfish (Semotilus corporalis), cheek chub (Semotilus atromaculatus), common shiner (Notropis cornutus), golden shiner (Notemigonus crysoleucas), silvery minnow (Hybognathus regius), smallmouth bass (Micropterus dolomieui), largemouth bass (Micropterus salmoides), bluegill (Lepomis macrochirus), red-breasted sunfish (Lepomis auritus), yellow perch (Perca flavescens), johnny darter (Etheostoma nigrum) and slimy sculpin (Cottus cognatus). Both brown and rainbow trout are planted annually in the Ashuelot River by the New Hampshire Department of Fish and Game. Brook trout were last planted in 1979.

Fish species that can be expected to occur in the Minnewawa Brook would include brook trout, which were last planted by the New Hampshire Fish and Game in 1973, brown bullhead (Ictalurus nebulosus), creek chub, fallfish, blacknose and longnose dace, johnny darter and slimy sculpin.

Small mammals expected to occur in the project area include the masked, smokey and northern water shrews (Sorex cinereus, S. fumeus, S. palustris), shorttail shrew (Blarina brevicauda), five genera of Bats (Myotis, Lasionycteris, Eptesicus, Pipistrellus, and Lasiurus), white-footed mouse (Peromyscus leucopus), deer mouse (P. maniculatus), woodland jumping mouse (Napaeozapus insignis), starnose mole (Condylura cristata), hairytail mole (Parascalops breweri), eastern chipmunk (Tamias striatus), and house mouse (Mus musculus). Medium-sized mammals would include opossum (Didelphis marsupialis), eastern cottontail and New England cottontail (Sylvilagus floridanus and S. transitionalis), raccoon (Procyon lotor), striped skunk (Mephitis mephitis), shorttail and longtail weasels (Mustela erminea and M. frenata), mink (M. vison), red fox (Vulpes fulva), eastern gray squirrel (Sciurus carolinensis), red squirrel (Tamiasciurus hudsonicus), beaver (Castor canadensis) and muskrat (Ondatra zibethica). Large sized mammals would include whitetail deer (Odocoileus virginianus) and black bear (Ursus americanus).

Fishery management in the Ashuelot River will eventually be affected by the Connecticut River Atlantic Salmon Restoration Program. This is a cooperative State-Federal effort begun in 1967 to restore and maintain Atlantic salmon (Salmo salar) in the Connecticut River Basin at levels sufficient to provide both natural spawning populations and sport fishery. The Ashuelot River is not one of the initial ten high priority streams designated for restoration (deferred status). However, once the long-term goal of full basin utilization is realized, fish passage will likely be required at the dams on the Ashuelot River. This would allow access to the project vicinity by not only Atlantic salmon, but also by the anadromous American shad (Alosa sapidissima).

Threatened and Endangered Species

In a letter dated 22 August 1988 from the U.S. Fish and Wildlife Service, the dwarf wedge mussel (Alasmidonta heterodon), soon to be proposed as an endangered species, is designated to be found below the Surry Dam. Surveys by the U.S. Fish and Wildlife Service of this basin for additional populations are underway. At the present time, the dwarf wedge mussel is a candidate species. The proposal to have it designated as a Federally endangered species is underway. As a proposed species, the Corps would be required to confer with the U.S. Fish and Wildlife Service for any action which could jeopardize the existence of the mussel. Once a species is accepted as an Federally endangered species, consultation under Section 7 of the Endangered Species Act of 1973 is required.

Preferred habitat for the dwarfed wedge mussel is moderately flowing fresh water and a firm substrate. This species is not likely to be found in silty substrate. The Nature Conservancy is conducting a monitoring program in the Ashuelot River Basin to determine the status of the dwarf wedge mussel.

Water Quality

Table 7 describes the State of New Hampshire Water Quality classifications. The New Hampshire Division of Water Supply and Pollution Control (NHWSPC) has two systems of classification, the Legislative Classification or goal and the Existing Water Quality. Most of the Ashuelot River and its tributaries are classified as Class B according to the Legislative Classification Map. The lower portion of the Ashuelot River, which extends approximately 10 miles upstream from the confluence of the Connecticut River, is classified as Class C. Three ponds in the watershed, Kilburn Pond, Goose Pond and Roaring Brook are classified as Class A.

The NHWSPC collects water samples in the Ashuelot River on a periodic basis to monitor water quality. Current data is presently being evaluated and a document is in preparation. Generally, existing water quality in the Ashuelot River violates water quality standards for fecal coliform bacteria and dissolved oxygen. This may be the result of sewage treatment facility effluent and in-town violations in the City of Keene. Water quality in the vicinity of Winchester violates Class B standards due to fecal coliform bacteria and possible toxicological concerns. There are sewage treatment facilities which discharge into the Ashuelot River in Keene, Winchester, Hinsdale and West Swanzey as shown in Plate 3.

A local organization called the Ashuelot River Monitoring and Protection Program (ARMPP) conducts regular sampling of the Ashuelot River to help assure that the river is fishable and swimmable. This information can also identify water quality violations allowing local and state officials work to improve it. An excerpt from their 1987 testing program sums up the results.

"On September 17, 1987 samples were collected and tested for fecal coliforms. Fecal coliforms are bacteria which serve as indicators of the presence of disease causing organisms. Fecal coliforms are found in the intestines of all mammals. They are present in great abundance in sewage. Water containing high levels of fecal coliforms are considered unsafe for recreational uses of a river, especially water contact recreation such as swimming. Fecal coliform levels greater than 126 per 100 milliliters (ml) of water are considered unsafe for water contact recreation by the U.S. Environmental Protection Agency."

"A second set of several sites was collected on October 9, 1987. Those samples were tested for total coliforms which are also bacterial indictors of possible sewage pollution. Total coliform levels greater than 240 per 100 ml are considered unsafe for water contact recreation by the State of New Hampshire."

Of the 18 sites (from Marlow to Winchester) tested for fecal coliforms on September 17, two sites in Keene exceeded the fecal coliform standard of 126 per 100 ml. Of the 6 sites tested (all in Keene) for total coliforms on October 9, one had levels exceeding the total coliform standard of 240 per 100 ml. It is not yet possible to determine the cause of the high coliform levels. The ARMPP may provide further insight into the Ashuelot River water quality violations through a historical approach with continued monitoring in their 1988 program.

TABLE 7

STANDARDS FOR THE CLASSIFICATION OF SURFACE WATERS OF THE STATE OF NEW HAMPSHIRE

Class A	Class A waters shall be of the highest quality and shall contain no more than fifty coliform bacteria per one hundred milliliters. There shall be no discharge of any sewage or wastes into waters of this classification. The waters of this classification shall be potentially acceptable for water supply uses after disinfection.
Class B	Class B water shall be of the second highest quality and shall have no objectionable physical characteristics, shall be near saturation for dissolved oxygen, shall contain not more than two hundred forty coliform bacteria per one hundred milliliters. There shall be no disposal of sewage or waste into said waters except those which have received adequate treatment to prevent the lowering of the physical, chemical or bacteriological characteristics below those given above, nor shall such disposal of sewage or waste be inimical to fish life or to the maintenance of fish life in said receiving waters. The pH range for said water shall be 6.5 to 8.0 except when due to natural causes. Any stream temperature increase associated with the discharge of treated sewage, waste or cooling water shall not be such as to appreciably interfere with the uses assigned to this class. The waters of this classification shall be considered as being acceptable for bathing and other recreational purposes and, after adequate treatment, for use as water supplies.
Class C	Class C waters shall be of third highest quality and shall be free from slick, odor, turbidity, and surface-floating solids of unreasonable kind or quantity shall contain not less than five parts per million of dissolved oxygen; shall have a hydrogen ion concentration within the range of pH 6.0 to 8.5 except when due to natural causes; and shall be free from chemicals and other materials and conditions inimical to fish life or the maintenance of fish life. Any stream temperature increase associated with the discharge of treated sewage, waste or cooling water shall not be such as to appreciably interfere with the uses assigned to this class. The waters of this classification shall be considered as being acceptable for recreational boating, fishing, or for industrial water supply uses either with or without treatment depending upon individual requirements.

Class D — Class D waters shall be of the lowest classification and shall be free from slick, sludge deposits, odors and surface-floating materials of unreasonable kind, quantity or duration, taking into consideration the necessities of the industries involved, and shall contain not less than two parts per million of dissolved oxygen at all times. Any stream temperature increase associated with the discharge of treated sewage, waste or cooling waters shall result in a receiving water temperature not in excess of 90 F. The waters of this classification shall be aesthetically acceptable. Such water shall also be suitable for certain industrial purposes, power and navigation.

ARCHAEOLOGICAL AND HISTORIC RESOURCES

Archaeological Resources

There are several prehistoric period archaeological sites dating from the last 11,000 years recorded along the Ashuelot River between Keene and Hinsdale. Some of the sites were noted by early European settlers in the region (e.g. the "Sand Bank" in Swanzey, and the "Squakheag Fort" in Hinsdale), while others have been more recently discovered by local amateur archaeologists. The amount of information about the sites varies. At least two sites have been professionally excavated, the rest have been reported as limited finds, or observed as they wash out of the river bank. Despite the lack of quality and quantity of information about these sites, some preliminary statements can be made about prehistoric Amerindian use of the Ashuelot River Valley.

The earliest documented habitation in the Ashuelot Valley is the Whipple Paleoindian site in Swanzey. It has been dated to 10,680± 400 years B.C. The Whipple site is located on a gently sloping terrace or deltaic deposit, 180 meters (590 feet) from the Ashuelot River. A small, spring fed brook borders the site, emptying into a lowlying marsh area between the site and the present river course. These early visitors to the valley were hunting caribou, and exploiting whatever floral resources that were available in the post-tundra, spruce parkland environment.

As the climate ameliorated, and species diversity expanded, Amerindian occupation of the valley continued and intensified. Evidence of prehistoric and proto-historic occupation have been reported along nearly every brook feeding into the Ashuelot, as well as on the high, sandy banks along the river. One particularly large site, known as the "Sand Bank" in Swanzey, is noted prominently in histories of the area. In the 18th century, the outline of a fortification or structure could still be discerned. Several Indian graves, of persons buried in a seated position, facing east were recorded as they were discovered during earthmoving operations. Sites have been reported along Ash Swamp Brook in Keene, California Brook in Swanzey, and on several sandy knolls along the main stem. Sites have also been reported near ponds in Swanzey and Winchester. A large stone dam, or fish weir is located in the Ashuelot River between the "Sand Bank" site (Sawyer's Crossing) and West Swanzey. This large, vee or "harrow" shaped structure, six to twelve feet thick, is presumed to have been used to aid in the harvesting of anadromous fish. A cache of Indian projectile points was discovered near this weir. The weir is now inundated by the pool created by the dam in West Swanzey, and was last seen when the pool was lowered to allow for repairs.

The majority of the sites probably represent brief (seasonal) occupations for most of the time periods represented. By the 15th or 16th centuries, some groups were probably beginning to clear small parcels for agriculture and were becoming semi-sedentary. Benjamin Read, in his "History of Swanzey, New Hampshire, from 1734 to 1890", (1892) reports that the Squakheag Indians had numerous settlements, usually near the banks of the larger streams, in locations favorable for hunting and fishing, raising corn and pumpkins. He also points out that the first European settlers "directed their attention to the meadow land in the Ashuelot above the Sand Bank and the north part of the meadow in the South Branch, indicates that those meadows were found to be in condition to be easily brought under cultivation". By the end of the 16th century, the native groups were probably well involved in the European fur trade, which had begun in the early 16th century, and had depleted the supply of beaver in large areas of New England before the settlement of the Europeans.

The many millenia of occupations by Amerindian groups have left prolific remains along the banks of the rivers and streams in the Ashuelot Valley. Many of these sites have already been destroyed either by the natural erosion action of the river, or by the hand of man. Construction, gravel and sand operations and "looting" of sites have all helped to remove large portions of the archaeological record, making any remaining sites all the more invaluable for discovering and interpreting the past. Sites in alluvial environments (i.e. Keene) may be deeply buried under more recent alluvium, and could only be detected with deep trenches. Downstream, in Swanzey, Winchester and Hinsdale, sites may be expected in the flood plain and on higher, dryer, sandy banks or knolls and can be found in plowed fields or exposed surfaces.

Any proposed alteration to the stream bank would require a careful inspection and documentation of historic disturbances to determine if there remains any potential for Amerindian sites. Some areas, such as the center of Winchester and parts of Hinsdale, where the banks of the river are defined by the walls of buildings, all prehistoric potential has probably been removed. There are, however, several areas in Keene and Swanzey, and stretches of the river in Winchester and Hinsdale, where sites may still remain along the river's edge.

Historic Resources

During the early 19th century through the early 20th century, the Ashuelot River was considered one of the most important manufacturing streams in New Hampshire. The river provided power for the cotton and woolen mills, pottery shops, shoe factories, paper mills, box factories and sawmills along its length from Keene to the confluence with the Connecticut River in Hinsdale. The manufacturers had access to major markets and were the primary employers for the river communities of Keene, Swanzey, Winchester and Hinsdale.

Keene was first settled in 1734 and was known as "the Upper Township on Ashuelot River". In 1739 this name was shortened to Upper Ashuelot. Upper Ashuelot was renamed Keene, by the governor in 1753. The name was taken from Sir Benjamin Keene, the English minister to Spain who some years previous had befriended the governor. In 1769, the province was divided into five counties. Keene became the shire town of Cheshire county, and by 1773 had a population of 645. By 1790 Keene had a population of 1314. The first grammar school was set up before 1793, a workhouse for the care of the poor was built by 1791 and in 1794 a company was formed by Abijah Wilder and Luther Ames to build an aqueduct. In 1796 water was brought from Beaver Brook to the village by way of these aqueducts for the town's water supply.

The Ashuelot River was cleared in 1819 to make it navigable for larger freight boats. Temporary locks were built around the falls between Winchester and Keene. A grant was obtained from the legislature by Lewis Page, and gave him the exclusive right to take tolls and navigate the Ashuelot from the Faulkner and Colony Mills to the Connecticut River. This allowed freight to be shipped directly by water between Hartford and Keene.

Keene's population in 1830 was 2374. Among the industries located in the town were Faulkner and Colony Mills, Azel Wilder's wheel head factory and Holmans pump factory (all located on the Ashuelot). There were also two pail makers, a potash manufacturer, a shingle maker, two glass factories and two tanneries.

Keene in 1850 had a population of 3392. With its numerous industries and direct railroad lines to Boston and New York, the town had the position as the most important town in Cheshire County. There were at least a dozen manufacturers located in Keene. In 1851 the American Telegraph Co. opened an office in Keene as part of its line from Boston, Massachusetts, to Rutland, Vermont.

According to the 1900 city directory there were six pail and pail stock manufacturers, three box makers, five chair shops, a tannery, a woolen mill and four sawmills. Keene had seen a steady increase in business and manufacturing concerns throughout the 19th century. This prosperity continued through the first half of the 20th century.

The town of Swanzey, originally known as Lower Ashuelot was settled in 1737 under a grant by the State of Massachusetts. Sixty three houselots were set up in 1734 and the proprietors were selected by a lottery. Permanent settlement occurred in 1737. By 1738 a small fort had been built around a Captain Hammond's house and a sawmill and gristmill were in operation. The township was chartered as part of New Hampshire on 2 July 1753 and was renamed Swanzey. The proprietors in 1760 granted the water privileges at West Swanzey to Captain Joseph Whitcomb. He erected a sawmill and gristmill. This property remained in operation and controlled by the Whitcombs until 1853. Otis Capron bought water rights and a plot of land from the Whitcombs for a fulling mill in 1786. This mill changed hands several times and was a wool carding mill, a wooden ware shop and a bucket factory before its closing in 1848. Between 1849 and 1866, there were two wooden ware shops, several sawmills, a chair factory, a pail factory, a bucket factory and two box manufacturers in West Swanzey. In 1866 a partnership was formed to purchase all the mill and water power at West Swanzey for manufacturing wool and cotton goods. This became known as the Stratton Mills Company which after various mergers was renamed the West Swanzey Manufacturing Company in 1887.

Industrial development in Swanzey began as early as 1780. The town had six discrete areas of development; West Swanzey and Westport on the Ashuelot River, East Swanzey and Swanzey Center on the South Branch, and Spragueville and Factory Village on Beaver Brook.

The first dam in East Swanzey on the South Branch was built around 1780 to power a saw and gristmill. From 1825 until 1848 these mills were used for manufacturing lumber for the Connecticut River trade. After 1850 the property changed hands several times and became the site of a clothes pin factory, a wool carding mill and a pail handle factory. Swanzey Center, on the South Branch, contained a large steam powered mill which housed a saw and grist mill, a pail shop and chair factory. The mill was in operation from about 1850 to 1864 when it was sold, taken down and rebuilt in South Keene.

There are two historic covered bridges located in Swanzey. Both span the Ashuelot River. The Sawyer's Crossing Bridge in East Swanzey was constructed in 1859 in a two span length of 159 feet. The West Swanzey bridge, of Twin lattice truss construction, was built in 1832. Both are still in use by pedestrians and motor vehicles.

The grant for Winchester, first known as Arlington, was issued on 21 June 1733. The proprietors of Arlington set out from Lunenburg, Massachusetts in 1735. A sawmill on Roaring Brook was built the previous year by Colonel Josiah Willard. This was the first mill in Winchester. The settlers abandoned the town in 1745 and returned to Lunenburg after the onset of the war between the French and English in 1744. The town was not resettled and reorganized until 1753, when the New Hampshire provincial government gave the proprietors and grantees assurances of protection against further Indian attacks. By 1780 the population of Winchester was 1103, and the town had established its own school districts. In 1802 the town had a turnpike connecting it with Swanzey and Keene and in 1811 the first post office in Winchester was established.

The village of Ashuelot, two miles west of Winchester, contained two hat factories, a satinet mill, a box factory and a steam saw mill. At various other points along the river there were at least twenty small steam or waterpowered sawmills which produced lumber for the markets in Winchester. The Ashuelot Covered Bridge was built in Winchester in 1864. It is a two span structure, 178 feet long, of Town lattice truss construction, and is listed on the National Register of Historic Places.

Hinsdale is one of the smallest towns in area in the state. The first house in the town was built by Daniel Shattuck in 1737. This was fortified and became known as Fort Shattuck. In 1745 the settlers were driven out by Indian hostilities and the settlement was not resettled until 1750.

The charter of Hinsdale was granted on 3 September 1753. Prior to this, it was part of the settlement of Northfield The town was named after Colonel Ebenezer Hinsdale a former chaplain at Fort Dummer. In 1742 he built Fort Hinsdale and a gristmill on the east side of the river. Two of the earlier occupations in Hinsdale were raftsmen and lumbermen. A road was constructed up the Ashuelot Valley from the ferry landing at Cooper's Point, at the confluence of the Ashuelot and Connecticut Rivers. Lumber was hauled by way of the valley road to the landing in Hinsdale then loaded onto boats. The raftsmen then manuevered the boats up the Connecticut River rapids between the Ashuelot and West Rivers. There were at least ten manufacturers in Hinsdale during the mid to late 19th century. These included two flannel mills, two manila paper mills, an iron foundry, a lawn mower factory, a carriage shop and a box factory. There were very few self-supporting farms in Hinsdale during the 19th century. Most of the population worked in the mills or shops along the Ashuelot and Connecticut Rivers.

The Ashuelot River has provided water power for many mills and business from Keene to Hinsdale since the area was first settled in the 1730s. It was described in the 19th century as one of the most important manufacturing streams in New Hampshire. Keene became an important commercial center and the economy of the villages of Swanzey, Winchester and Hinsdale was based on manufacturing. The entire length of the river, from Keene to Hinsdale has the potential to contain historical archaeological sites. Numerous mills are still extant and some are being used for other purposes such as restaurants and shopping malls.

SECTION III - PROBLEM IDENTIFICATION

An initial task of the study process is the identification of water resources problems and opportunities in the Ashuelot River Basin. Particular attention is given to those water resource problems beyond the ability of local citizens to solve. Once these problems have been identified, opportunities to reduce these problems are developed to determine potential solutions within the mutual roles and interests of Federal and non-Federal sponsors.

Field inspections, discussions with local citizens and representatives of the State of New Hampshire yielded the identification of flooding damage as the significant water resource problem currently existing within the Basin. Subsequently, the attention of this investigation focused on flood related problems and opportunities of flood damage reduction with structural and nonstructural solutions.

A flood damage survey was performed in Keene, Winchester and Marlborough, New Hampshire, during May and June, 1988 by an NED damage evaluator. Flood related losses were estimated for each floodprone structure and site beginning at the elevation at which discernable losses and damages are first incurred up to the flood elevation of a rare and infrequent (500 year) event. The reference point at each structure was the first floor elevation. Ground and first floor elevations for most properties were obtained. Interviews were conducted for commercial, industrial and public activities. For residential properties, use of sampling, typical loss profiles by type of house and minimal interviewing were employed. Both physical and non-physical losses were estimated. Also, the cost of emergency services and damages to transportation, communication and utility systems were obtained where possible.

FLOOD DAMAGE AREAS

Flood stages from the 1984 and 1987 events generally exceeded the river banks 3 feet or less and resulted in inundation of thoroughfares, parking lots and driveways, flooded basements and wet first floors of structures and evacuation of properties in low lying areas. Some structural damages were sustained and disruption of normal transportation patterns occurred. The flood stages of the 1984 storm were comparable to a flood event between the 50-year and 100-year frequency on the lower Ashuelot. While flooding experienced in 1987 was less severe than in 1984 on the lower Ashuelot, flooding was experienced on the Minnewawa Brook and downstream of Surry Mountain Lake.

Keene, New Hampshire

Flood damages occurred upstream of Faulkner and Colony dam and throughout the floodplain of southern Keene. In northern Keene above the Faulkner and Colony dam, Tanglewood Estates, a mobile home park, experienced water levels which exceeded first floor elevations. South of this site and still north of the Faulkner and Colony dam, Harper Acres, a community housing project, experienced water levels that caused ponding atop the access road but remained below the first floor elevations of the structures. Immediately below the Faulkner and Colony dam between West Street and Winchester Street, flood waters entered basements of residential properties and ponding occurred at or adjacent to a few commercial and industrial structures on both sides of the Ashuelot River. South of Winchester Street within the Keene flood plain, commercial and residential structures experienced flooding about 2 feet or less above first floor levels. These areas included Martel Court, the area east of Ash Swamp Brook and areas adjacent to the Branch River. Stage-Frequency Curves of the Ashuelot River at various locations throughout Keene are shown in Plates 13, 14 and 15.

Winchester, New Hampshire

During the May/June 1984 flood, street flooding in Winchester closed State Route 10 in several locations and caused minor damage to residential structures near Howard and Elm Streets as well as to residential structures north of the center of town. A few commercial developments in the center of town and adjacent to the Ashuelot River experienced flood damage that was mostly limited to basement levels. Another damage area was at a shopping mall adjacent to Mirey Brook near its confluence with the Ashuelot River. Flood depths were about 2 feet above first floor levels in June 1984. A Stage-Frequency Curve of the Ashuelot River in the central area of Winchester is shown in Plate 12.

Marlborough, New Hampshire

Flood damages in the community of Marlborough were found to exist at two sites. These sites were subject to flooding from the Minnewawa Brook, a sub-tributary of the Ashuelot River. These sites experienced similar damages caused by the 1984 and 1987 flood events. One site, located east of the center of town along Route 101, experienced flood waters that caused ponding atop the parking lot and river stages slightly above first floor levels. This site included three commercial structures. The other site located immediately downstream of Water Street bridge experienced flood waters that were backed up from the bridge. This caused ponding at Water Street and to an adjacent parking lot and resulted in water levels about 3 feet or less to four commercial and five residential structures. Stage-Frequency Curves of the Minnewawa Brook in Marlborough are shown in Plates 16 and 17.

PROJECTED FLOOD DAMAGES

Recurring Losses

Recurring losses are those potential flood related losses which are expected to occur at various stages of flooding under present day development conditions. As the final output of the flood damage survey process, recurring losses are expressed as an array of dollar losses, in one foot increments, from the start of damage to the elevation of the rare (500-year) event. Total recurring losses for selected events in the three basin towns under study are displayed in Table 8.

TABLE 8

RECURRING LOSSES

Recurring Losses - By Event

Location	10 year	50 year	100 year	500 year
Marlborough	$ 71,000	$ 203,000	$ 271,000	$ 398,000
Keene	$ 107,000	$ 843,000	$3,797,000	$7,962,000
Winchester	$ 5,000	$ 111,000	$ 360,000	$1,154,000
Total	$ 183,000	$1,157,000	$4,428,000	$9,514,000

Annual Losses

The purpose of estimating annual losses is to measure the severity of potential flooding on an "expected annual" basis in each damage center. Annual losses are the integration and summation of two sets of data at each damage location. Recurring losses for each flood elevation (event) are multiplied by the annual percent chance of occurrence that each specific flood elevation (event) will be reached. The effectiveness of each alternative flood reduction plan is measured by the extent to which it reduces annual losses . The average annual losses of the three towns are estimated to be about $145,000 and are presented in Table 9.

TABLE 9

ANNUAL LOSSES

Location	Annual Losses
Marlborough	$ 24,000
Keene	109,000
Winchester	12,000
Total	$145,000

FLOOD HISTORY

Damaging floods have occurred along the Ashuelot River and its tributaries since the first settlements in the basin. Minor floods are frequent, usually due to intense rainfall, or a combination of rainfall and melting snow. Floods develop quickly. Experience gained from the regulation of Surry Mountain and Otter Brook Lakes indicates that floods on the Ashuelot River at the Keene flood plain crest about 8 hours after an intense rainfall.

Two major floods, experienced in the Ashuelot River basin prior to the completion of Surry Mountain Lake in October, 1941, occurred in March, 1936 and September, 1938. A brief description these and other historic floods are noted below:

March 1936

The largest volume flood of record in the Ashuelot River occurred between 9 and 22 March 1936. The winter's snow cover in the basin was much heavier than normal, as little thawing had occurred during January and February of that year. Temperatures became unseasonably warm on the 9th of March and remained so during the remainder of the month. Total rainfall at Keene for the period 9 to 22 March was 5.97 inches. This rainfall, along with melting snow with a water content of approximately 7 inches, contributed to a runoff of 11.8 inches at the mouth of the river in Hinsdale for the period 12 to 31 March. The peak discharge at Hinsdale was 16,600 cfs.

September 1938

The flood that produced the greatest peak flows in the Ashuelot River occurred on 21 September 1938. A hurricane was preceded by nearly a full week of precipitation which saturated the soil with 1.70 inches of rain between the 13th and 17th of the month. The hurricane itself deposited 7.43 inches of rain at Keene between the 18th and 22nd. Total runoff associated with the storm at Hinsdale was 5.2 inches. This rainfall event produced major flooding along all tributaries, but most notable the South Branch and Beaver Brook.

April 1960

The month of April opened with deep snow cover over the watershed due to heavy March snowfall and abnormally cold temperatures. Water equivalent in the snowpack ranged up to 10 inches in the headwaters of the upper tributaries. A period of warm weather and moderate to heavy rain began on 30 March and continued until 6 April. Average rainfall over the basin was nearly 4 inches for that period. Flood regulation at Surry Mountain Lake resulted in a peak stage of 54.8 feet and 71 percent of its storage utilized. This storage was equivalent to 4.2 inches of runoff.

April 1969

Water content in the snow cover preceding the April 1969 flood was extremely high . A maximum water equivalent of 9.6 inches was reached on 1 March (the highest recorded value for that date). This had depleted only to 6.2 inches by 1 April. The monthly rainfall for April was 3.70 inches at Keene, 3.14 inches at Surry Mountain Lake and 4.37 inches at Otter Brook Lake. During a 48-hour period, 1.69 inches of intense rain fell at Otter Brook, 1.22 inches at Keene, and 0.87 inch at Surry Mountain. The flood caused a volume of water storage of 71 percent at Otter Brook Lake and 73 percent at Surry Mountain Lake. Total runoff for the month of April at Hinsdale was 9.07 inches.

May/June 1984

During the last week of May a large, slow moving storm system passed through New England bringing rainfall during Memorial Day that continued for approximately a week. Precipitation amounts experienced in the Keene area were from 9 to 10 inches between 29 May and the 2 June. This rainfall produced extensive flooding along the Ashuelot from Keene to Hinsdale. The peak discharge recorded at Hinsdale was 10,100 cfs and was the largest since construction of the Surry Mountain and the Otter Brook flood control reservoirs. Flood regulation at Surry Mountain Lake resulted in a peak stage of 61.4 feet with 89 percent of its storage utilized. This storage was equivalent to 5.3 inches of runoff. Significant flooding also occurred along the Beaver Brook tributary.

March/April 1987

During a one-week period beginning at the end of March, 1987, a pair of intense rainstorms hit most of New England, causing major flooding in Connecticut, Massachusetts, New Hampshire, Vermont, and Maine. These two storms, augmented by snowmelt in the mountains and northern areas, resulted in widespread flooding. On 31 March, a fast-moving storm system buffeted the entire New England area with heavy rainfall, strong southerly winds and temperatures in the 50's and 60's. The storm system deposited 3 to 5 inches of rain in southern and coastal areas and 2 to 3 inches of precipitation over much of northern New Hampshire and Vermont, both of which had 3 to 5 inches of water equivalent in their remaining snowpacks. On 4 April, another intense but slow-moving storm hit southern and much of central New England with a heavy rainfall of 4 to 7 inches. This 4-day storm created a classic one-two flood punch. Flood regulation at Surry Mountain Dam resulted in a peak stage of 66.1 feet (1.1 foot over spillway crest) with over 100 percent of its reservoir storage utilized. This storage was equivalent to 6.14 inches of watershed runoff. Also, regulation at Otter Brook Lake resulted in over 100 percent of its reservoir storage utilized. A maximum stage of 99.4 feet (1.4 feet over spillway crest) was experienced.

FUTURE CONDITIONS WITHOUT FEDERAL PARTICIPATION

It is anticipated that future conditions of flood damage will be more severe. The patterns of economic and population growth and the desirability to locate near major transportation routes have caused a significant increase of new occupancy in existing flood plains adjacent to the river. Flooding is presently modified by storage in existing flood control reservoirs and temporary storage in natural flood plain areas. As evidenced by the flood events of 1984 and 1987, this system does not prevent but rather reduce damages caused by flooding. The existing flood plain hydrology combined with a loss of natural flood plain storage and an increase in flood plain occupancy indicates that flood damages in and downstream of the flood plains will be greater in the future.

Under existing conditions, a certain amount of water accumulation within the flood plain is necessary to provide the hydraulic conveyance for flood plain drainage. The flood waters from the uncontrolled drainage areas accumulate in the flood plains. During the period when inflows exceed outflow, water storage and river stages increase. This condition prevails until outflow exceeds inflows. Thereafter, river stages and water storage in the flood plain abate.

Earlier Corps of Engineers sponsored investigations have led to the completion of four flood control projects. Two of these projects, Surry Mountain Lake and Otter Brook Lake, are flood control reservoirs located upstream of the flood plains. These projects have significantly contributed to flood damage reduction as they store a large portion of flood waters which would otherwise converge in the flood plains. The release of these stored waters occur after the river stages recede. The Beaver Brook Project and the Local Flood Protection Project along the main stem of the Ashuelot River also contribute to flood damage reduction.

The Ashuelot River Basin has a well established recurring flood problem, particularly in the central and lower-central segments where there exists large natural flood plains. The largest flood plain is situated in southern Keene where three major tributaries converge onto the main stem of the Ashuelot River. Further downstream in the lower-central segment of the basin, another flood plain exists in the community of Winchester. These flood plains serve to store excessive runoff, reduce peak river stages and gradually release waters as the flood stage recedes.

Losses in flood plain storage impair the flood plain functions and raise several concerns. Reduction of flood plain storage will increase river levels for a given flood event within and downstream of the flood plain. Consequences include possible changes to groundwater recharge patterns, alteration to existing wetlands and disruption to the ecosystem. Another important concern deals with an increase in flood damage vulnerability to new and existing resources located in the flood plains and resources not currently situated in the present flood plain. New resources located in the flood plain add to the present ecomomic risk; existing resources in the flood plain become more susceptible to flood damage; resources not currently considered to be located in the flood plain may become subject to flood damage; and, resources located downstream of the flood plain will be subject to higher river levels, especially during major flood events.

The flood plain which is currently experiencing the most accelerated growth is located in southern Keene. The City of Keene is aware that it faces a potential for increased flooding and that it has a major responsibility for approving flood plain developments.

In the past, Keene has sought and received Federal assistance from the US Army Corps of Engineers, the Soils Conservation Service and the Federal Emergency Management Agency. Also, the City's Conservation Commission has bought 800 flood prone acres along the Ashuelot River above the Faulkner and Colony Dam which is now within the Ashuelot River Park. Recently, Keene has requested additional assistance from the Federal Emergency Management Agency to provide detailed technical evaluation of the flood plain hydrology and quantification of river stage impact from construction encroachment. However, the time required to perform such a study compared to the rate of flood plain encroachment may not identify the magnitude of impact in a timely manner. It would be prudent to prevent further loss of the existing flood plain until that time in which a study is completed. Options available to prevent further loss of the existing flood plain include adoption of more restrictive or comprehensive flood plain management criteria such as tightening zoning requirements and implementing requirements of compensatory flood plain storage.

STATEMENT OF PROBLEMS AND OPPORTUNITIES

The resolution which authorized the investigation of the Ashuelot River Basin provided the basis for identification of the problems and opportunities in the study area. Identified needs in this report were modified based upon an assessment of current conditions and coordination with local, regional, State and Federal agencies and the general public.

As an initial guide to the formulation of alternative plans, the following objectives were set forth:

a. Reduce future inundation damages caused by flooding in the Ashuelot River Basin.

b. Enhance water quality and water supply including irrigation, recreation, and aesthetic settings in the Ashuelot River Basin where possible.

c. Assist in the preservation of the environmental, cultural and natural resources within the Ashuelot River Basin.

d. Foster an improved economic climate in the region.

SECTION IV - PLAN FORMULATION

DEVELOPMENT OF ALTERNATE PLANS

During the course of this water resources investigation, numerous meetings were held with the State of New Hampshire officials and representatives of several communities within the Ashuelot River Basin. The purpose of these meetings was to identify water resource problems including flood damage from the 1984 and 1987 floods of reference as well as to inform the public at large of the investigation being conducted by the US Army Corps of Engineers.

The information from these meetings in combination with field surveys conducted by the US Army Corps of Engineers indicated that flooding was the significant water resource problem and identified several locations that were subject to impact from flood waters. An initial screening of these sites was conducted to determine which sites and alternatives warranted further study. Factors considered during this process included the potential for flood damage, the potential environmental and social impacts, engineering feasibility and public acceptability of identified alternatives. This process was conducted in conjunction with the Department of Environmental Services of New Hampshire, Division of Water Resources.

Flood damages occurred throughout areas adjacent to the Ashuelot River in Keene and Winchester and at various locations adjacent to the Minnewawa Brook in Marlborough. Other areas within the watershed experienced flooding; however, the lack of flood damage potential precluded further consideration of these sites for evaluation of flood damage reduction alternatives.

The Ashuelot River Basin currently has flood control projects in existence; namely, Surry Mountain, Beaver Brook and Otter Brook Lake. Since flooding continues to be a problem, a series of additional flood damage reduction alternatives were formulated and evaluated to determine economic feasibility. These alternatives may be generally classified into structural and nonstructural alternatives.

STRUCTURAL ALTERNATIVES

Structural alternatives are characterized by preventing or reducing inundation of the flood plain. Structural alternatives investigated include the deauthorized flood control project (Honey Hill Lake), by-pass conduits, channel improvements, and concrete walls and earthen dikes.

Flood Control Reservoirs

A review of past studies was performed to identify the structural option of flood control reservoirs. Based on this review, one flood control reservoir, Honey Hill Project, was found to have been given previous consideration but not constructed. This Corps of Engineers project called for the construction of a dam that would have been located on the South Branch of the

Ashuelot River in the town of West Swanzey about 5.6 miles upstream of the confluence with the Ashuelot River. With the reservoir filled to spillway crest (elevation 524.0 feet NGVD) the reservoir pool would have inundated an area of 1,360 acres, including part of East Swanzey. It was estimated during past Corps of Engineer studies that the Honey Hill reservoir would have reduced flood stages of a recurring 1936 flood by 1.0 feet in Keene and 1.7 feet in Winchester. The location of this previously proposed reservoir is shown in Plate 1.

By-Pass Conduits

By-pass conduits are channels or tunnels that convey flood waters away from or around potential damage areas. A by-pass channel was initially considered as an alternative method to reduce flooding in Winchester. Due to the flat grades and river hydraulics, the required length and capacity of the by-pass conduit would result in a project costs far outweighing benefits. This project has a benefit cost ratio of less than .01 and is not economically justified. Elsewhere in the Ashuelot River Basin, the application of by-pass conduits were not considered due to a combination of factors including economic feasibility and availability of land.

Channel Improvements

Channel Improvements as a structural alternative are characterized by physical changes to the river that occur between the ordinary high water marks. Examples of channel improvements include modifying existing control facilities and widening and/or deepening the river. Several channel improvements were examined as flood damage reduction alternatives and are described as follows:

(1) West Swanzey - Keene

Questions have been raised in the past as to the effect the Dickinson Dam in West Swanzey has on flood elevations in Keene and it has been believed that if minor modifications to the dam were made, it could reduce flood levels in Keene. Therefore, the reach of river from the dam upstream through the Keene flood plain was analyzed to answer long standing questions. Recognizing the complex hydraulics of high flows through a large flood plain area, it was decided to use the National Weather Service Dam-Break Flood Forecasting Model. This program has the capability of routing flood hydrographs through a reach and providing information on the attenuation of peak flows, timing, and resulting peak flood levels.

Input to the model consisted of river cross-sections used for the West Swanzey and Keene Flood Insurance Studies, Mannings "n" coefficients ranging from 0.03 to 0.045 for the channel and 0.06 to 0.08 for overbank areas. The model was calibrated by analyzing the September 1938 flood. Previously developed, unmodified by Surry Mountain and Otter Brook flood control projects, flood hydrographs were routed through the storage reach resulting in a reasonable reproduction of observed flood levels within the flood plain. Once this was completed, the recurring September 1938 flood, after construction of Surry Mountain and Otter Brook flood control projects, was analyzed. Again there was relatively close agreement between modified flood elevations previously estimated by Corps studies and those computed by the model. Once these calibrations were completed, a series of alternatives were investigated.

It was assumed that major modifications to the Dickinson Dam were made, such as installation of a bascule type gate whereby a recurrence of the September 1938 flood elevation would be lowered about 3 feet at the dam. A gate approximately 160 feet long and 3 feet high would be required. The model was executed assuming this modification was in place. Results indicate that water levels would quickly return to existing conditions and stage reductions within the flood plain would be negligible.

Another analysis assuming total removal of the dam was performed. The model was re-executed resulting in stage reductions immediately upstream of the dam in Swansey; however, further upstream within the major portion of the Keene flood plain, stage reductions were insignificant.

Other improvements involving channel modifications including excavation were assumed, but stage reductions within the Keene flood plain were found to be minimal. The extremely flat gradient of this reach of river severely limits any stage reductions that would result from an improved channel. Also, from surveyed high-water marks of historic flood events, it is known that tailwater elevations at Dickinson Dam exceed the elevation of the spillway crest during major flood events. Total gradient from the Dickinson Dam tailwater to Keene is only about 6 to 7 feet, in a distance of about 9 miles. Thus, it was concluded that modification to the dam and any channel work along this large reach of river would have minimal impact on reducing flood elevations in Keene.

(2) Winchester

The existing Ashuelot River channel in Winchester drops about 3 feet in a length of about 14,000 feet. This flat slope results in relatively large depths of ponding during flood events. Questions were raised concerning the flooding of a shopping mall adjacent to Mirey Brook and whether the flooding was due overbank flooding of Mirey Brooks or to the backwater effect of the Ashuelot River. A hydrologic evaluation of the area concluded that the flooding was the result of backwater from the Ashuelot River.

An alternative was evaluated that consisted of a channel improvement starting downstream of Bolton Road at an invert elevation of 417 feet NGVD and ending upstream of Howard and Elm Street at an invert of about 423 feet NGVD, for a total improved channel length of about 14,000 feet. A site location map of the channel modification alternative for Winchester is shown in Plate 7. A trapezoidal channel with an 80 foot bottom width and 1 to 2 side slopes would be needed to convey the 100-year discharge of 9270 cfs at a depth of 20 feet and a velocity of 4.0 feet per second. Such a channel would lower the 100-year flood elevation about 2 feet in the center of Winchester and at the shopping mall adjacent to Mirey Brook. The average excavation required in deepening the river would be about 3 feet. The existing water profile and modified water profile of the Ashuelot River at Winchester is shown in Plate 10.

(3) Marlborough

Two channel modification alternatives were formulated and evaluated for the two flood damage locations in this community. The first alternative was formulated for a section of Minnewawa Brook at a location adjacent to Route 101. A site location map of the channel modification alternative is shown in Plate 8. This alternative consists of increasing the width to the existing channel bottom from 16 feet to 25 feet with 1 on 2 side slopes to convey the 100-year discharge of 3,000 cfs at a depth of about 6 feet and velocity of 16 feet per second. The channel modification would be about 400 feet long. This improvement would lower the 100-year flood level about 2 feet.

The second alternative was formulated for a section of the Minnewawa Brook located immediately downstream of Water Street. A site location map of the channel modification is shown in Plate 9. This alternative consists of deepening the Brook by an average of 3 feet and would include the removal of a small concrete weir and concrete wall downstream of the Water Street Bridge. The total length of channel improvement would be about 700 feet. This alternative would lower 100-year level about 3 feet. The existing water profiles and modified water profiles of the Minnewawa Brook in Marlborough are shown in Plate 11.

Walls and Dikes

Concrete walls and earthen dikes are structural alternatives which prevent flood waters from reaching developed areas. Typical cross sections used for wall and dike alternatives are shown in Plate 4. These designs are based on heights of the structures less than 10 feet. These designs did not include additional costs associated with land acquisition, interior drainage and pumping capacities as part of the initial evaluation. Alternatives were formulated so that earthen dikes had 3 feet of freeboard and concrete walls had 2 feet of freeboard above the 100-year flood elevation. Earthen dikes have a lower construction cost per linear foot than concrete walls, but require more land for development and can not always be developed due to close proximity to existing structures.

Since the hydraulic characteristics of the Ashuelot River throughout Keene preclude the application of channel modification methods, walls and dikes were considered to be the most practicable structural method of flood damage reduction. All potential damage areas were examined and evaluated to determine the type of structural alternative that would be most appropriate. In Keene at the Harper Acres location and areas east of Ash Swamp Brook, wall and dike alternatives were not evaluated since the areas are low lying and closure from floodwater was not economically feasible. A description of the alternatives that were evaluated follows:

(1) Tanglewood Estates

An alternative consisting of an earthen dike was evaluated as a means of flood protection for this mobile home park. A site location map is shown in Plate 5. A dike about 1,900 feet in length would be required, extending from the Route 12A embankment to high ground at the southern end of Tanglewood Estates. To provide a 100-year level of protection with the necessary freeboard, a dike with a height of about 6.5 feet is required.

(2) Martel Court

An alternative consisting of a combination of concrete walls and an earthen dike was evaluated for this residential commercial area. A site location map is shown in Plate 6. The total length of the walls and dikes would be about 2000 feet with each barrier being of about equal length. The walls and dikes would extent from Routes 9,10 and 12 to Main Street. To provide a 100-year level of protection with the necessary freeboard, a height of about 6 feet above existing grade would be necessary for the earthen dikes and a height of 4 feet above existing grade would be required for the concrete walls.

NONSTRUCTURAL ALTERNATIVES

Nonstructural flood control measures prevent or reduce physical flood damages without significantly altering the nature or extent of flooding. Nonstructural alternatives investigated included flood proofing techniques such as raising the structures above the flood datum and installing seals to allow dry barriers to the structure and reviewing action programs such as evacuation and regulations of flood plain development. A description of the various techniques follows.

Raising of Structures

Structures are elevated above the existing flood datum to eliminate flood damages to the structure and its contents. Structures with basements would have the utilities relocated, and the basement would then be filled in with suitable material. The structures would then be raised to one foot above the flood level. This method is assumed to be applicable to structures that are wood-framed and do not exceed height of 1 1/2 stories. During this investigation only one site, Tanglewood Estates in Keene was found to have structures suitable for the floodproofing measure, since this site contains mobile homes. All other sites generally consisted of structures made of masonry or were 2 stories or more in height.

Dry Barriers

Alternatives of dry floodproofing consists of water proof seals to attain dry barriers for a structure includes installing closures to windows, doors and other potential water entrance zones. This would consist of providing flood shields with stiffeners and watertight gaskets and installing structural frames permanently anchored to each building. For this investigation, the evaluation of this method took into consideration whether the structure was constructed of masonry or wood. This method of floodproofing was considered for the structures located in potential damage sites.

Action Programs

Action programs are defined as strategies to reduce flood losses by implementing procedures to respond to a flood threat. These programs would include forecasting, warning and evacuation as well as regulations of flood plain use and development. These programs do not eliminate flooding to structures but give sufficient warning for residents and businessmen to relocate assets to reduce damage from flood waters. Currently, the action programs employed by these communities are the participation in the National Flood Insurance Program and a flood warning and evacuation system.

The communities downstream of the Surry Mountain Flood Control Project which include the City of Keene participate in the National Flood Insurance Program. These communities are responsible for approving all proposed flood plain developments and for assuring that necessary permits required by Federal and State law have been received. Although these communities may set higher standards for construction or may limit development in flood plain areas, these communities do not appear to have adopted more stringent criteria than the minimum criteria established by the National Flood Insurance Program. Although community planning is making efforts to evaluate the impact of storage loss in the flood plain, there are no community regulations such as zoning or compensatory storage requirements which prevent further losses to the existing flood plain.

SECTION V - PLAN EVALUATION

ECONOMIC CONSIDERATIONS

Structural Alternatives

The economic evaluation of structural alternatives is shown in Table 10. The alternatives were formulated to provide protection from the 100 year flood event. The costs, benefits and resultant benefit cost ratios have been determined for six sites in the basin. These sites include two in Keene, two in Marlborough, one in Winchester and one in Swanzey, N.H..

The total costs are amortized for a project life of 100 years at an interest rate of 8 7/8 percent and include in-place costs, contingency, engineering and design and supervision and administration costs. For structural alternatives consisting of walls and/or dikes, the benefits are the annual losses prevented under existing conditions up to the specific level of protection (elevation) plus 50 percent of the free board range. For structural alternatives consisting of channel modification, benefits are the difference in annual losses determined from the natural and modified stage-frequency curves. For the Honey Hill Reservoir alternative, the first cost was determined by updating past estimates with the appropriate cost indices. Benefits associated with this alternative are the reduction in annual losses with the reservoir versus the existing conditions.

With exception to the Route 101 Site in Marlborough, the benefit cost ratios of the structural alternatives are less than unity and, therefore, are not economically justified. The Route 101 Site has a benefit cost ratio of 1.3 with a total cost of $80,500 and a net benefit of $2,700.

TABLE 10

ECONOMIC EVALUATION OF STRUCTURAL ALTERNATIVES

Alternative/ Location	First Cost ($1000)	Annual Cost ($1000)	Annual O.& M. ($1000)	Total Cost ($1000)	Annual Benefits ($1000)	Benefit to Cost Ratio	Net Benefit ($1000)
Reservoir/ Honey Hill Swanzey, N.H.	45,000.	3,994.	-	3,994.	146.	0.04	Neg.
Earthen Dike/ Tanglewood Estates Keene, N.H.	701.	62.2	4.	66.2	41.	0.62	Neg.
Dike & Wall/ Martel Court Keene, N.H.	1,600.	142.	2.5	144.5	1.	0.01	Neg.
Channel Mod/ Ashuelot Riv. Winchester, N.H.	6,700.	595.	10.	605.	5.1	0.01	Neg.
Channel Mod/ Route 101 Marlborough, N.H.	80.5	7.1	1.	8.1	10.8	1.33	2.7
Channel Mod/ Water Street Marlborough, N.H.	154.	13.7	1.5	15.2	8.7	0.57	Neg.

Nonstructural Alternatives

The economic evaluation of nonstructural alternatives is shown in Table 11. The alternatives were formulated to provide protection from the 100 year flood event. The costs, benefits and resultant benefit cost ratios have been determined for five sites in the basin. These sites include two in Keene, two in Marlborough one in Winchester.

The total costs are amortized for a project life of 50 years at an interest rate of 8 7/8 percent and include in-place costs, contingency, engineering and design and supervision and administration costs. For nonstructural alternatives consisting of raising the structure, the benefits are the difference in annual losses with the first floor at its existing elevation versus its raised elevation of 1 foot above the 100 year flood level. For nonstructural alternatives consisting of dry floodproofing benefits are reduced annual losses for damage categories that dry floodproofing would affect, namely contents and structure.

The benefit cost ratios for the nonstructural alternatives were found to be less than unity.

TABLE 11

ECONOMIC EVALUATION OF NONSTRUCTURAL ALTERNATIVES

Alternative/ Location	Total Costs ($1000)	Annual Costs ($1000)	Annual Benefits ($1000)	Benefit to Cost Ratio
Raising of the Structure/ Tanglewood Estates Keene, N.H.	1,275.	115.	15.0	0.13
Dry Floodproofing/ Tanglewood Estates Keene, N.H.	277.	25.	10.6	0.42
Dry Floodproofing/ Martel Court Keene, N.H.	46.	4.1	1.0	0.24
Dry Floodproofing/ Winchester, N.H.	153.	13.8	4.2	0.30
Dry Floodproofing/ Route 101 Marlborough, N.H.	75.	6.8	5.7	0.84
Dry Floodproofing/ Water Street Marlborough, N.H.	66.	5.9	2.8	0.47

ENVIRONMENTAL CONSIDERATIONS

Structural Alternatives

Structural alternatives have a greater potential impact to the environment than those of nonstructural measures for flood damage reduction. The greater potential impact associated with the implementation of structural measures include disruption of wetlands, alteration of riparian aquatic and forest habitat and changes to the basin hydrology. The potential impacts from earthen dikes and walls would include the direct physical loss of habitat and water quality degradation. The potential impact from channel modifications would include direct mortality to aquatic life-forms, permanent habitat loss and temporary water quality degradation.

The two flood prone areas in Keene considered for structural measures for flood reduction were Tanglewood Estates and Martel Court. These sites contain a band of riparian vegetation and provide fish and wildlife habitat. The riparian forest offers high quality nesting, foraging and hiding cover for small birds and mammals. It also serves as an important buffer area between the housing developments and adjacent wetlands, filtering urban runoff and acting as an audiovisual barrier. The impacts associated with construction of earthen dikes and concrete walls would be a direct loss of habitat from construction and temporary construction related impacts such as noise, dust and water quality degradation (sedimentation and turbidity). Due to the high value of riparian and palustrine wetland, construction in these areas could have a significant impact to fish and wildlife habitat. Location of the dikes and walls in already disturbed areas, leaving riparian vegetation intact, would reduce the level of impacts.

The structural measures considered at the two sites in Marlborough are channel modifications. The uplands along the river in these areas have been disturbed in the past and as a result, vegetation cover is limited. As well, recent (i.e. 1987) channelization work performed by the town of Marlborough further reduced cover vegetation along the stream below the project areas and disrupted the instream faunal community when unconsolidated streambed material was pushed up on the stream banks. The impacts associated with channel modifications could include direct mortality to fish and aquatic organisms, habitat loss due to loss of riparian wetlands and natural spawning features, and temporary impacts to downstream habitat and water quality degradation.

Due to the current level of habitat destruction in the Marlborough area, channel modifications would probably not impact fish and wildlife habitat significantly if performed in the near future (as the stream recovers over time, these impacts will increase). It is recognized that a permanent solution to the flooding problem in that area may have long-term benefits to fish and wildlife populations by reducing flooding related turbidity, sedimentation and habitat disturbances. To reduce environmental impacts of channel modifications, sediment and erosion control devices would need to be established during construction. In addition, this could be an opportunity to restore degraded habitat by placement of instream structures to recreate pools and riffles, and by seeding grasses and planting hydrophytic shrubs along the stream banks to control erosion and provide food, cover and shade.

The downtown section of Winchester is subject to flooding. This section contains residential and commercial structures located in the flood plain along the Ashuelot River. The foundations of these buildings, in many cases are constructed within the natural river banks and now form the river channel. The Kulick Country Mall, located along Route 78 is also subject to flood flows originating at the confluence of the Ashuelot River and Mirey Brook. The application of dikes and walls as a structural measure are not feasible because the lack of relief which limits the available tie backs for closures for the structures. Thus a channel modification scheme was evaluated as the most viable structural alternative. This alternative would impact a considerable portion of the Ashuelot River and would include direct mortality to aquatic life-forms and, disruption to habitat and water quality degradation.

<u>Nonstructural Alternatives</u>

The prevention or reduction of flood damages through the use of nonstructural alternatives such as flood proofing and action programs have no direct impact on the aquatic environment. Flood proofing has the least environmental impact of all the alternatives.

SECTION VI - CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

This study has investigated the water resources problems and opportunities of the Ashuelot River Basin in southwest New Hampshire. Examination of these problems has led to the determination that potential flood damage, particularly in the central and lower-central segments where there exists large natural flood plains, poses a significant concern.

Flood damage reduction alternatives were formulated and evaluated to determine technical merit, economic feasibility and possible environmental and social impacts. With exception to one site in Marlborough, New Hampshire, structural flood damage reduction alternatives were found not to be economically feasible. Nonstructural flood damage reduction alternatives were found not to be economically at all sites.

The structural alternative found to be economically feasible in Marlborough consists of a channel modification measure. This modification consists of widening the Minnewawa Brook in an approximate 400 foot length of channel. The cost of this measure is estimated to be $80,500 and a corresponding benefit cost ratio of 1.3. Due to the relatively small magnitude of cost associated with this project, Corps participation under the General Investigation program has not been recommended. However, there is a continuing authority program, Section 205 of the Flood Control Act of 1948, available to the community that could be utilized to further investigate this improvement if the community so desired.

This study perceives that future conditions of flood damage will be more severe in and downstream of the flood plains. Economic and population growth have led to a significant increase of new occupancy in the flood plains resulting in losses to natural floodwater storage areas. This concern is particularly acute in southern Keene, N.H., where there exists a large natural flood plain. Currently, Federal assistance has been requested by Keene to evaluate the potential impact from construction encroachment. Meanwhile, Keene should give consideration to community regulations such as zoning or compensatory storage requirements programs that would prevent further losses to the existing flood plain until such an evaluation is completed.

RECOMMENDATIONS

In as much as this investigation has determined that flood damage reduction alternatives were either not economically justified or have such a low implementation cost, I recommend that no further study under the General Investigation Program be pursued at this time.

I recommend that the study authority under Congressional resolutions adopted 26 September 1984 by the committee on Environment and Public Works of the United States Senate be closed.

10 August 1989
Date

DANIEL M. WILSON
Division Engineer

ACKNOWLEDGMENTS

This study was conducted by the New England Division, Army Corps of Engineers, under the general supervision of Mr. Joseph L. Ignazio, Chief, Planning Division and Mr. Donald W. Martin, Chief, Basin Management Branch and the direct supervision of Michael F. Keegan, Chief, Long Range Planning Section. Investigations were performed by an interdisciplinary project team. Persons primarily responsible for the contents of this report were: David Sward, project manager; John Yen, hydrology; Richard Ring and David Keddell, economics; Judith Johnson, environmental assessment; Marie Lynn Bourassa, archaeology, Ronald Defilippo, geology; Mark Desousa, design.

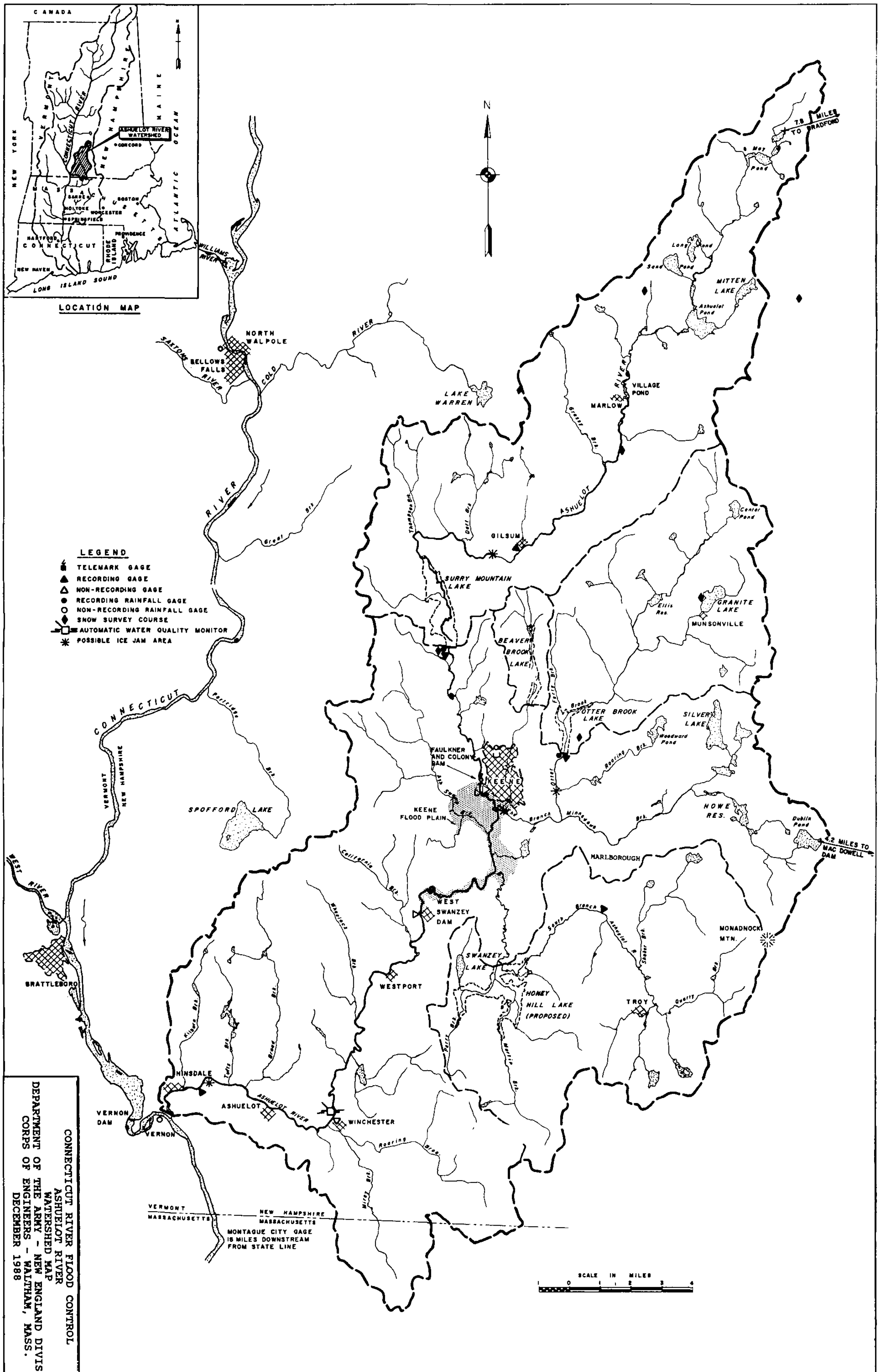
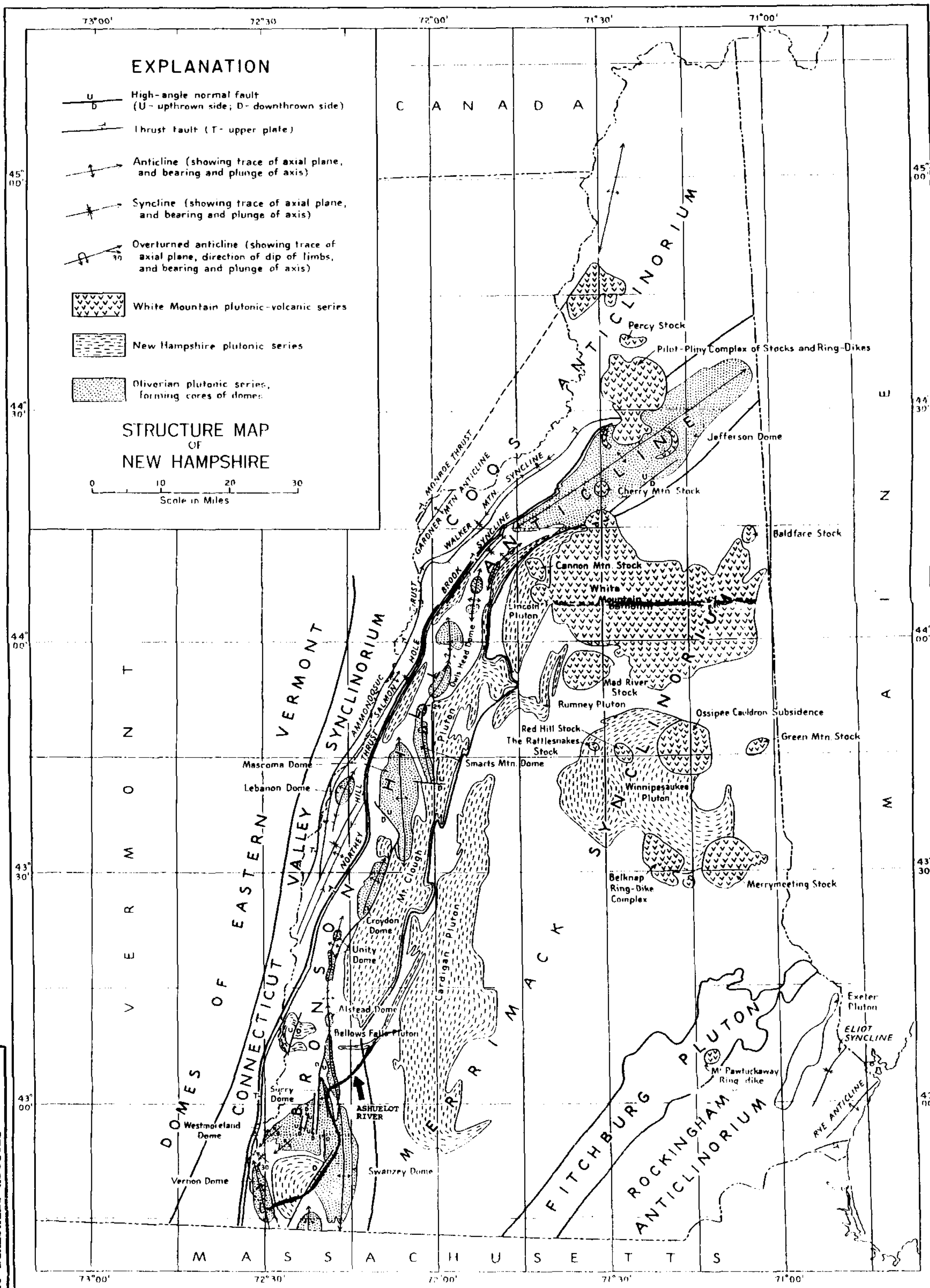
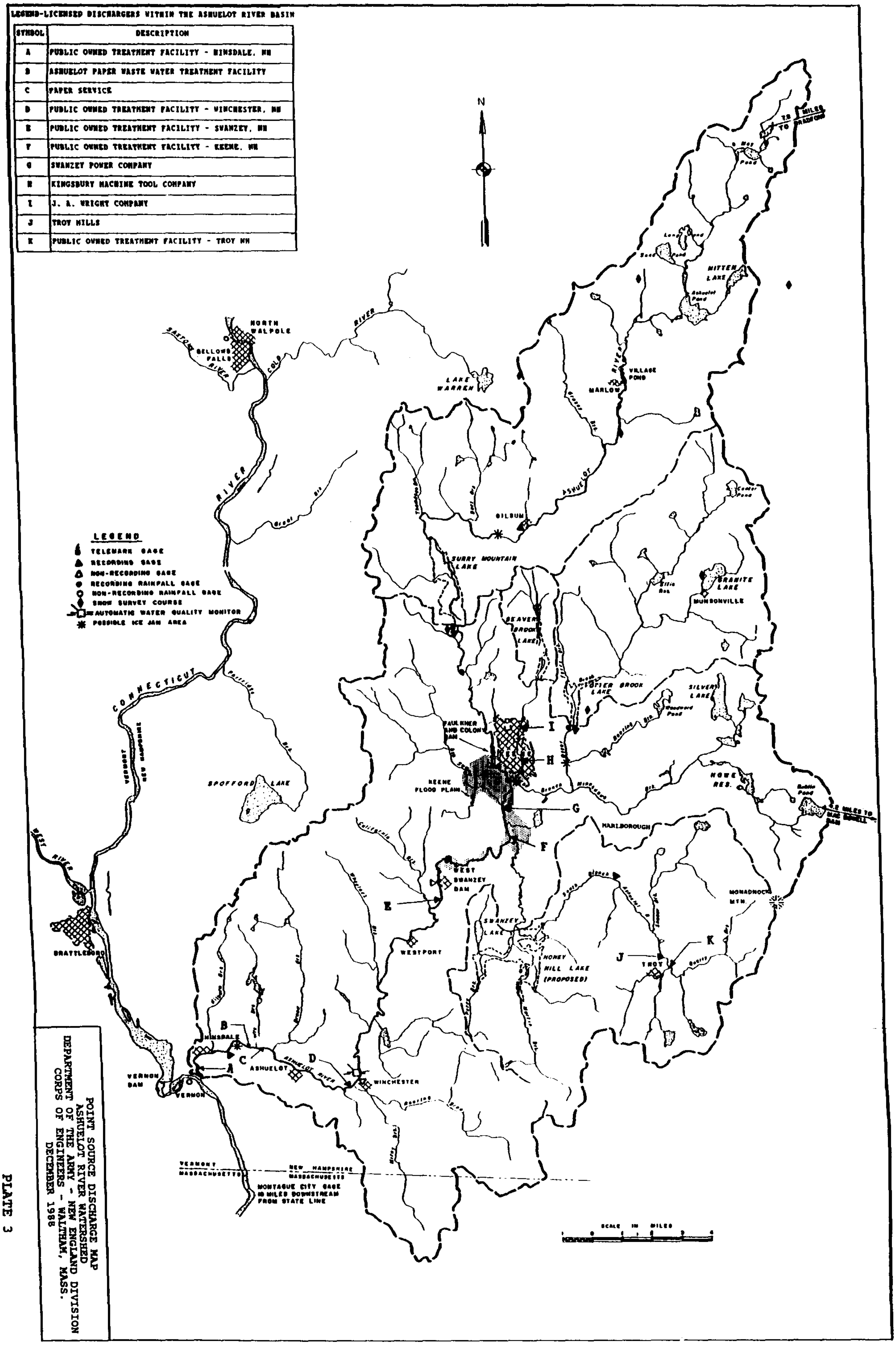

CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER
WATERSHED MAP
DEPARTMENT OF THE ARMY - NEW ENGLAND DIVISION
CORPS OF ENGINEERS - WALTHAM, MASS.
DECEMBER 1988
LOCATION MAP
CANADA
VERMONT
NEW HAMPSHIRE
MAINE
NEW YORK
CONNECTICUT RIVER
ASHUELOT RIVER WATERSHED
CONCORD
BOSTON
WORCESTER
SPRINGFIELD
HOLYOKE
BARRE
HARTFORD
CONNECTICUT
RHODE ISLAND
PROVIDENCE
NEW HAVEN
LONG ISLAND SOUND
ATLANTIC OCEAN
LEGEND
TELEMARK GAGE
RECORDING GAGE
NON-RECORDING GAGE
RECORDING RAINFALL GAGE
NON-RECORDING RAINFALL GAGE
SNOW SURVEY COURSE
AUTOMATIC WATER QUALITY MONITOR
POSSIBLE ICE JAM AREA
N
7.5 MILES TO BRADFORD
MITTEN LAKE
Ashuelot Pond
Sand Pond
Long Pond
WILLIAMS RIVER
NORTH WALPOLE
BELLOWS FALLS
SAXTONS RIVER
COLD RIVER
LAKE WARREN
VILLAGE POND
MARLOW
ASHUELOT RIVER
GILSUM
SURRY MOUNTAIN LAKE
GRANITE LAKE
MUNSONVILLE
Ellis Res.
BEAVER BROOK LAKE
OTTER BROOK LAKE
SILVER LAKE
Woodward Pond
FAULKNER AND COLONY DAM
KEENE
KEENE FLOOD PLAIN
HOWE RES.
Dublin Pond
4.2 MILES TO MAC DOWELL DAM
MARLBOROUGH
CONNECTICUT
SPOFFORD LAKE
VERMONT
NEW HAMPSHIRE
WEST RIVER
WEST SWANZEY DAM
SWANZEY LAKE
HONEY HILL LAKE (PROPOSED)
MONADNOCK MTN.
BRATTLEBORO
WESTPORT
TROY
HINSDALE
ASHUELOT
ASHUELOT RIVER
WINCHESTER
VERNON DAM
VERNON
VERMONT
MASSACHUSETTS
NEW HAMPSHIRE
MASSACHUSETTS
MONTAGUE CITY GAGE IS MILES DOWNSTREAM FROM STATE LINE
SCALE IN MILES
1 0 1 2 3 4

PLATE 1



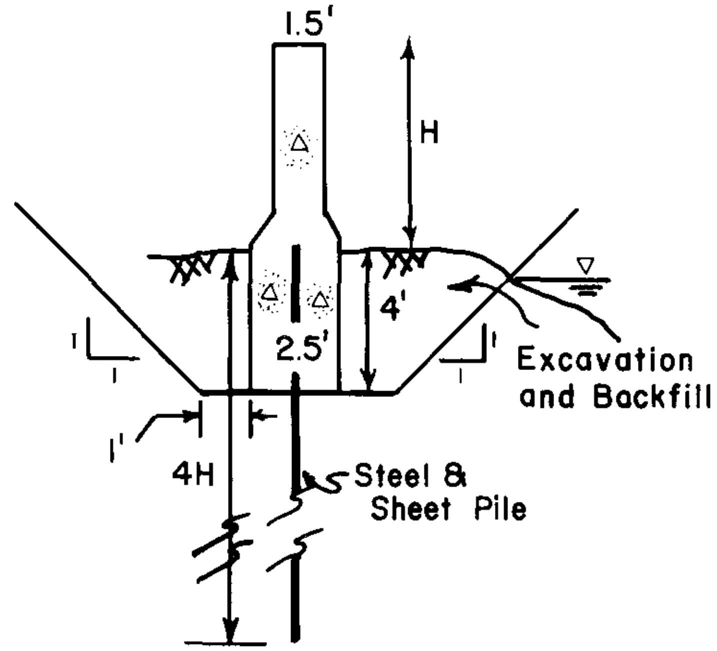
BEDROCK STRUCTURE OF NEW HAMPSHIRE (1)
DEPARTMENT OF THE ARMY - NEW ENGLAND DIVISION
CORPS OF ENGINEERS - WALTHAM, MASS.
DECEMBER 1988
(1) THE GEOLOGY OF NEW HAMPSHIRE, M.P. BILLINGS, 1956

PLATE 2

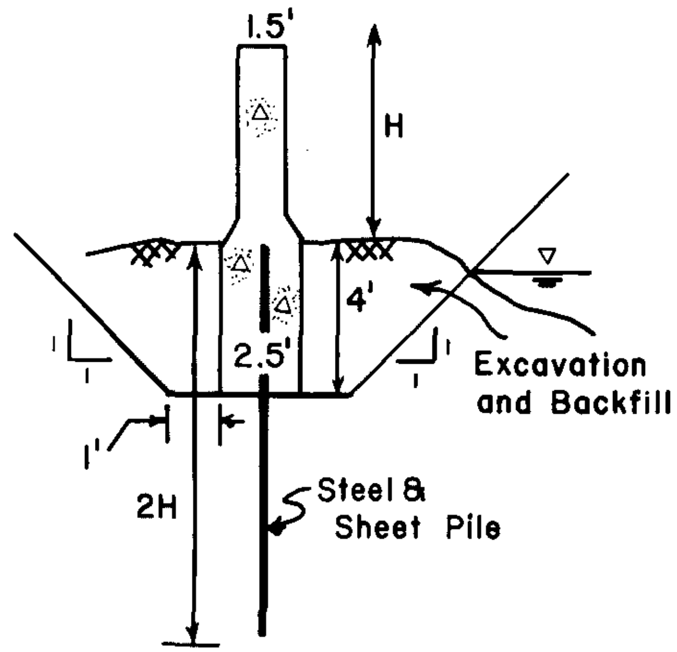


POINT SOURCE DISCHARGE MAP
ASHUELOT RIVER WATERSHED
DEPARTMENT OF THE ARMY - NEW ENGLAND DIVISION
CORPS OF ENGINEERS - WALTHAM, MASS.
DECEMBER 1988

PLATE 3

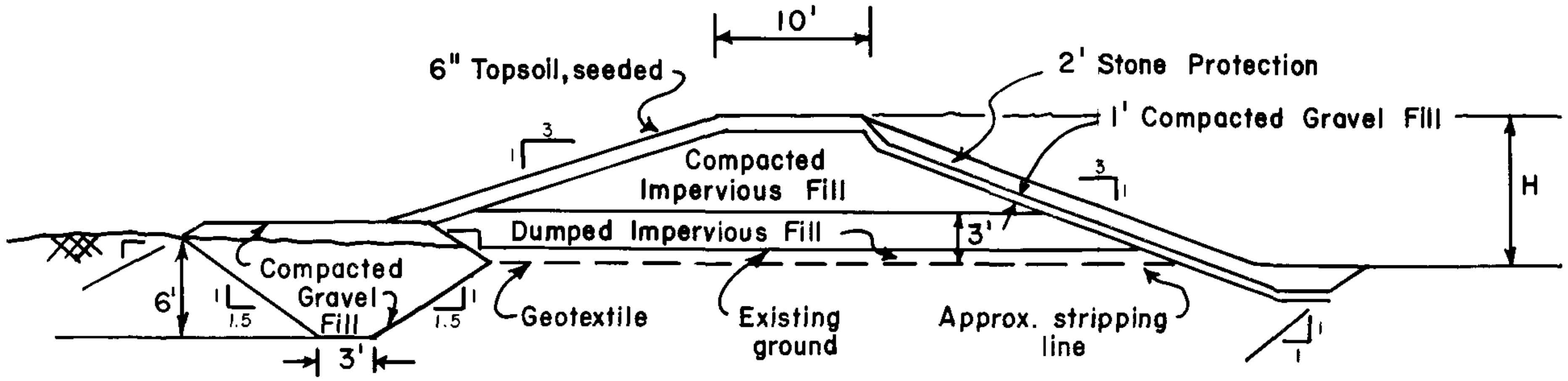


Poor Soil Bearing Capacity



Good Soil Bearing Capacity

CONCRETE I-WALL DESIGNS - TYPICAL

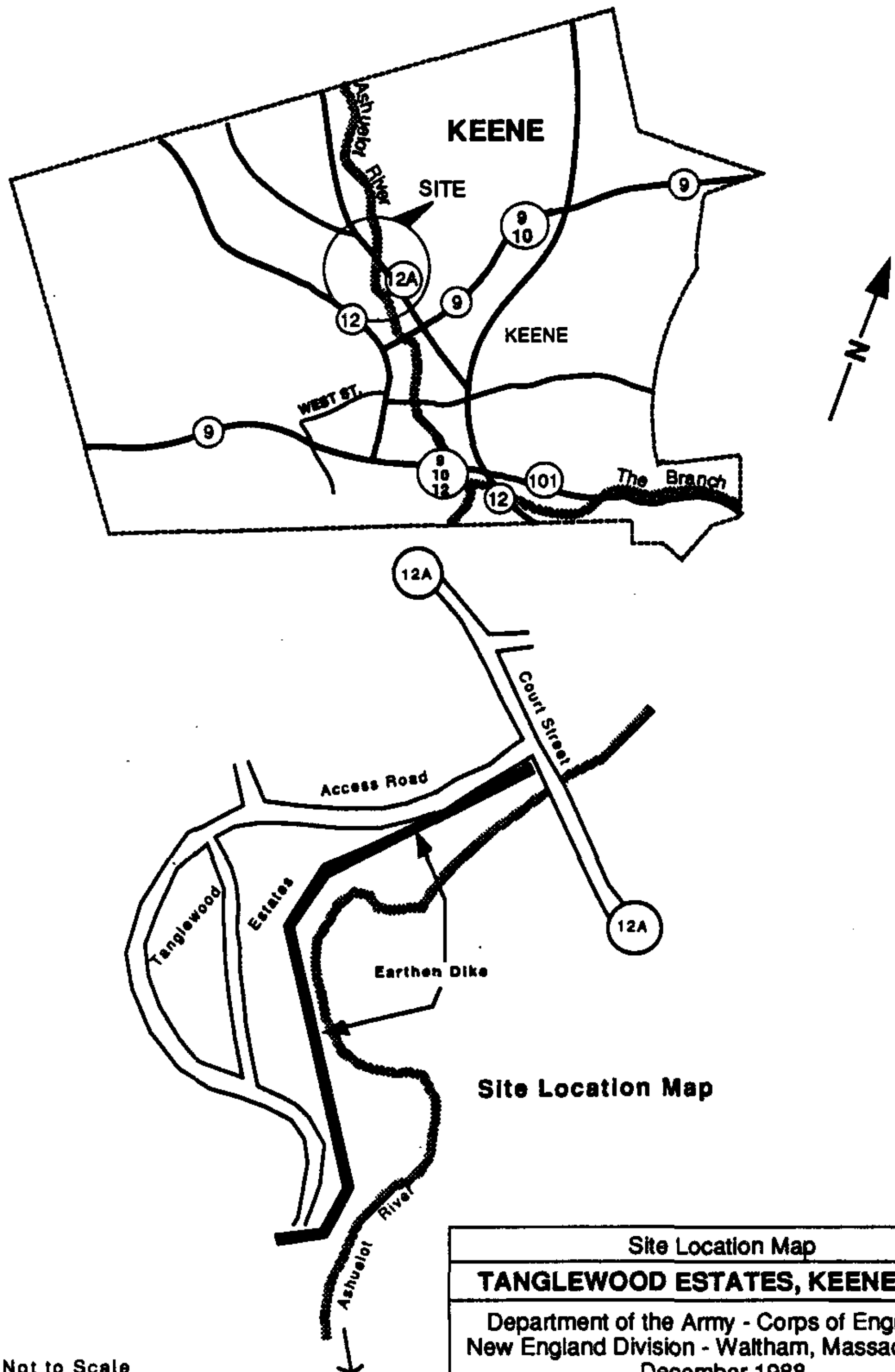


EARTHEN DIKE DESIGN - TYPICAL

NOTES: 1.) Height (H) of all structures is ≤ 10 feet and includes free board.
2.) Drawings are not to scale.

TYPICAL STRUCTURAL CROSS-SECTIONS
ASHUELOT RIVER BASIN

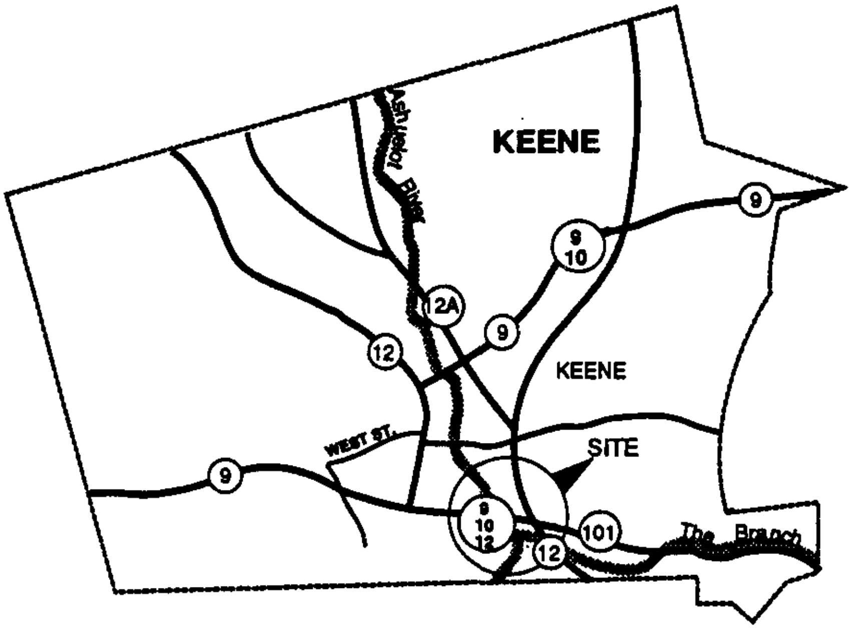
DEPT. OF THE ARMY- NEW ENGLAND DIVISION
CORPS OF ENGINEERS- WALTHAM, MA
DECEMBER 1988

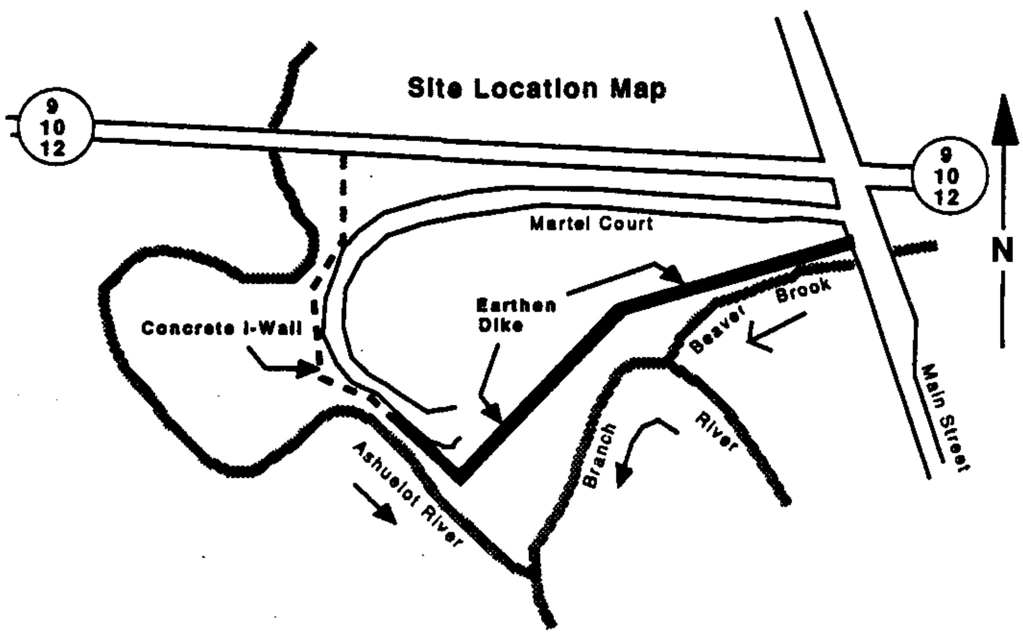


Site Location Map

TANGLEWOOD ESTATES, KEENE, N.H.

Department of the Army - Corps of Engineers
New England Division - Waltham, Massachusetts
December 1988

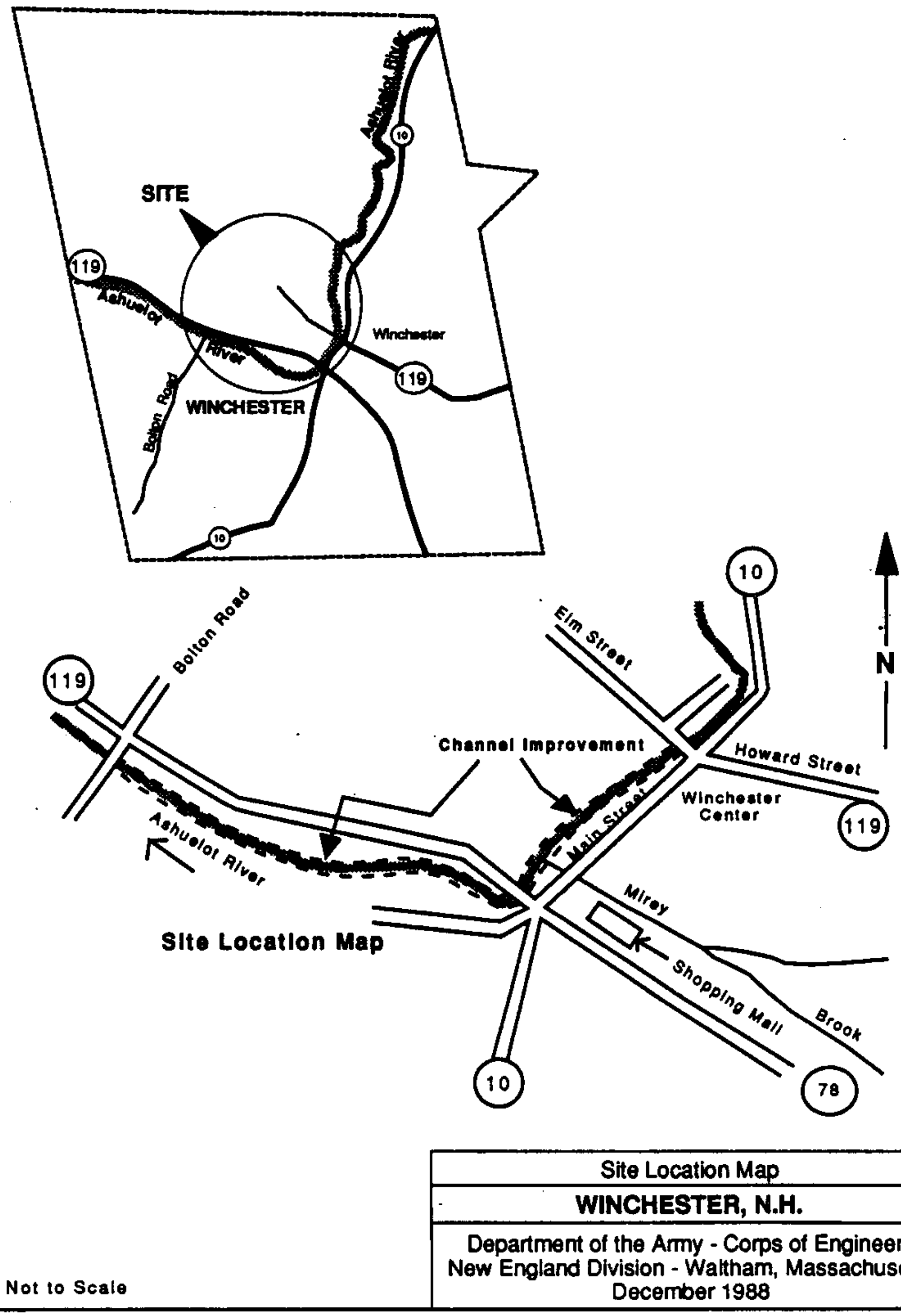




Not to Scale

Site Location Map
MARTEL COURT, KEENE, N.H.
Department of the Army - Corps of Engineers New England Division - Waltham, Massachusetts December 1988

PLATE 6

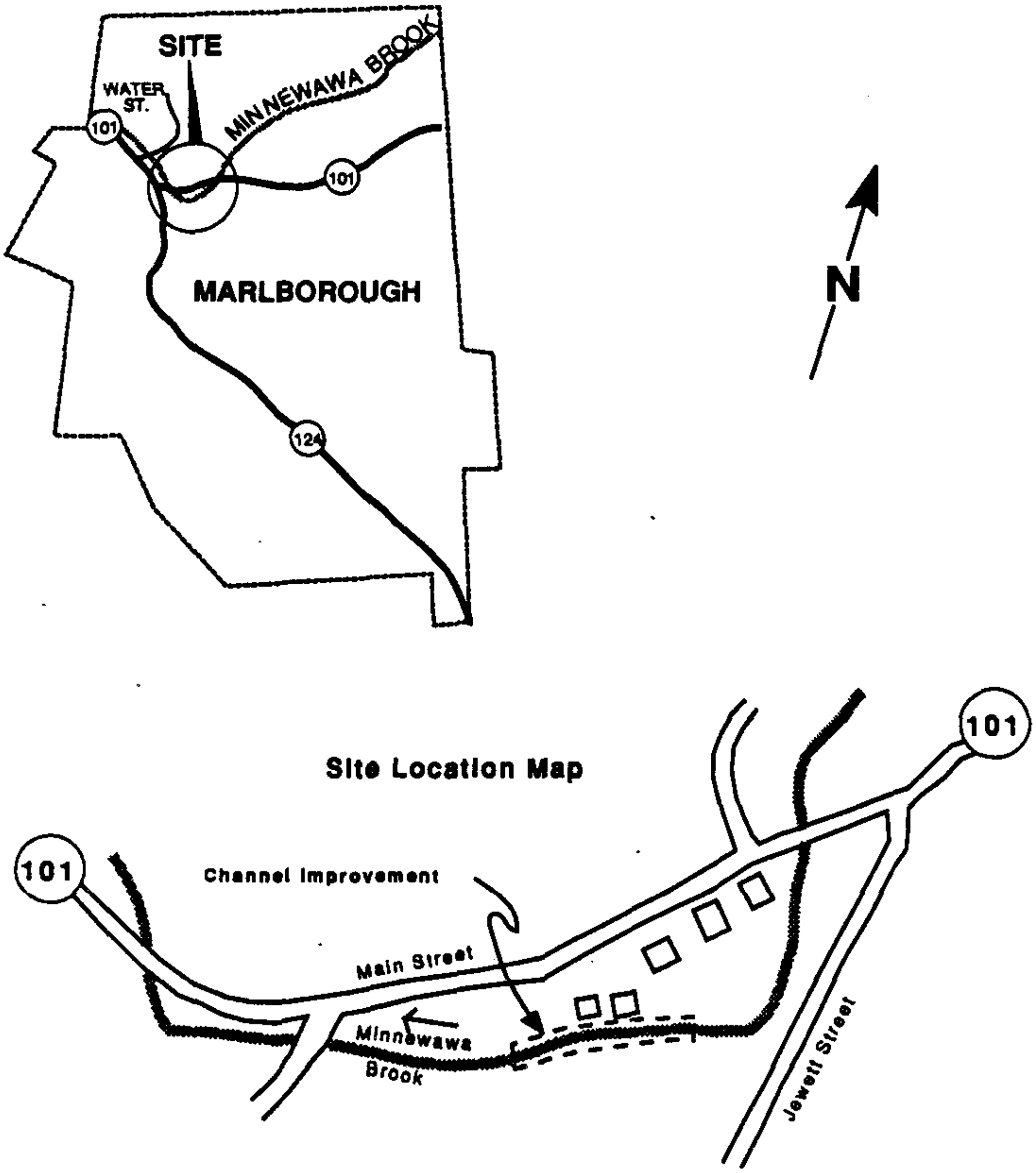


Site Location Map

WINCHESTER, N.H.

Department of the Army - Corps of Engineers
New England Division - Waltham, Massachusetts
December 1988

PLATE 7



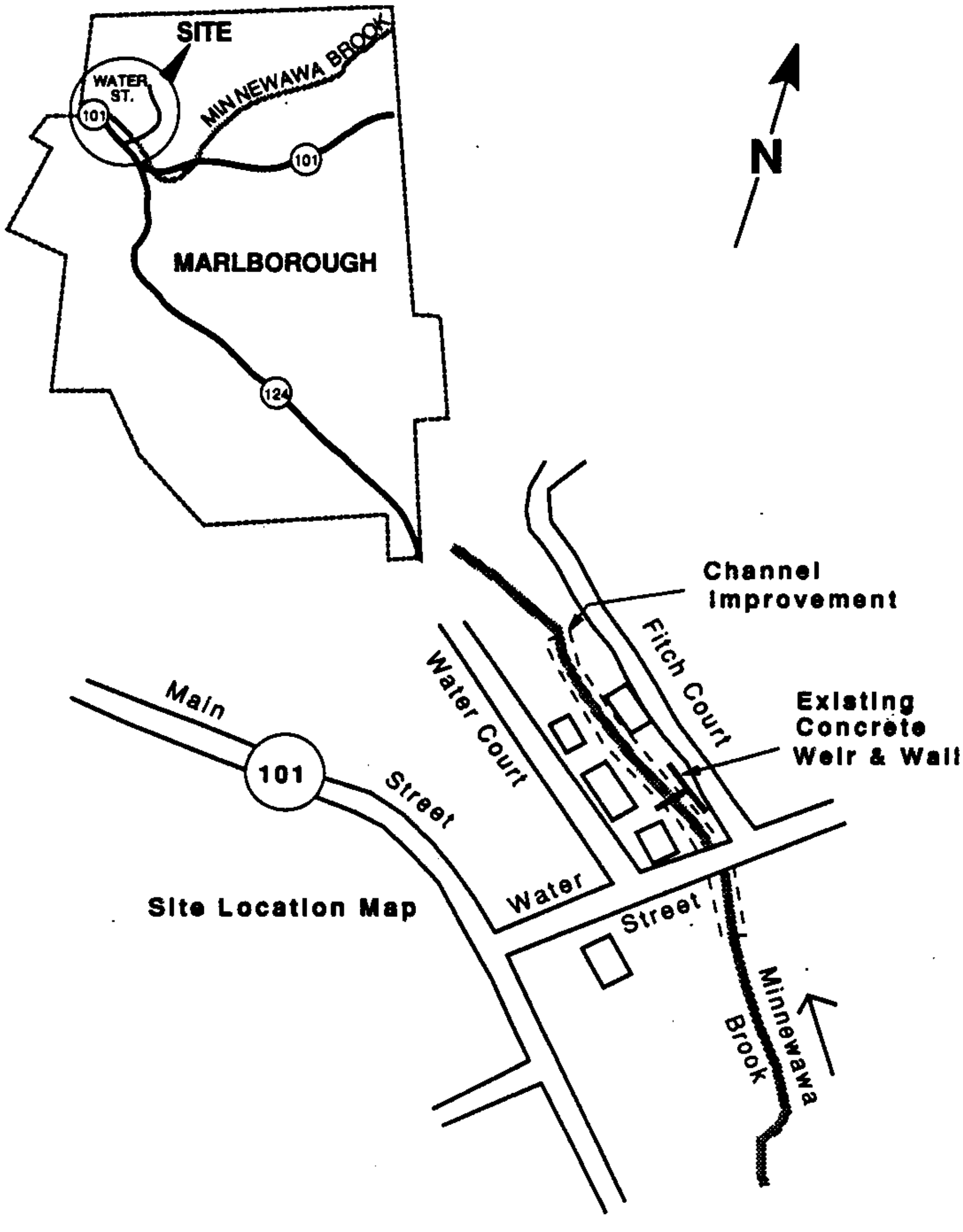
Not to Scale

Site Location Map

ROUTE 101, MARLBOROUGH, N.H.

Department of the Army - Corps of Engineers
New England Division - Waltham, Massachusetts
December 1988

PLATE 8



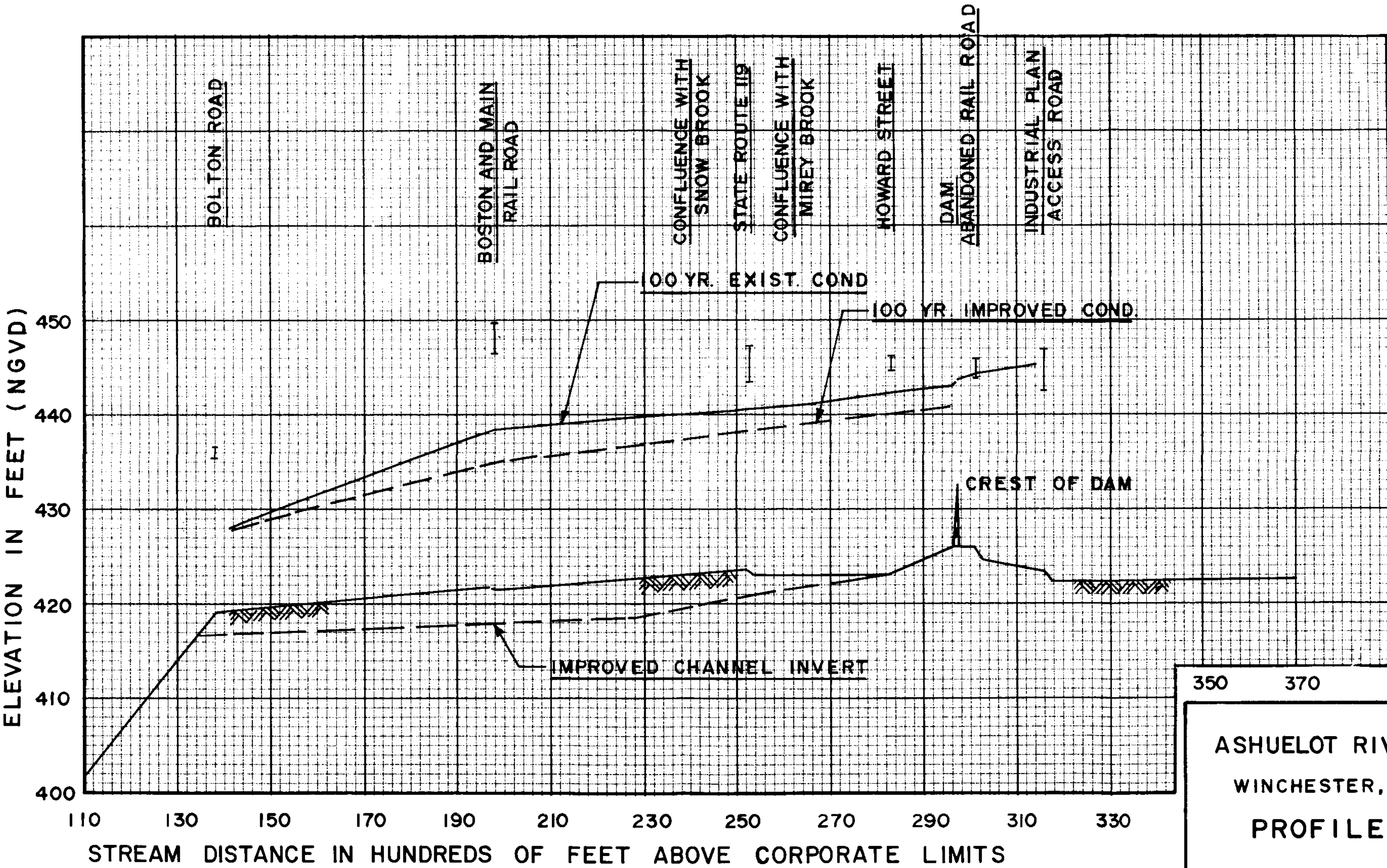
Not to Scale

Site Location Map

WATER STREET, MARLBOROUGH, N.H.

Department of the Army - Corps of Engineers
New England Division - Waltham, Massachusetts
December 1988

PLATE 9



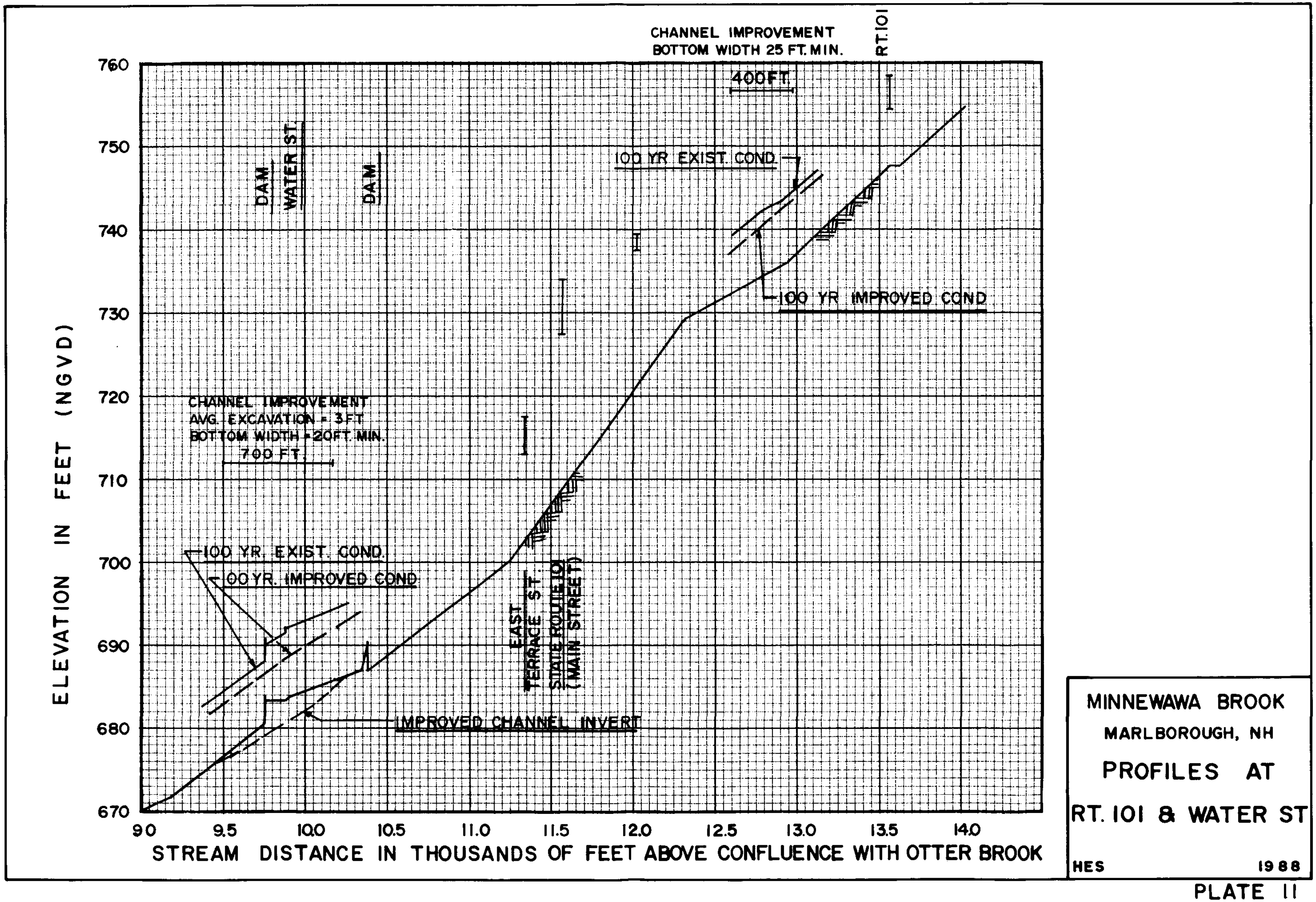
ASHUELOT RIVER

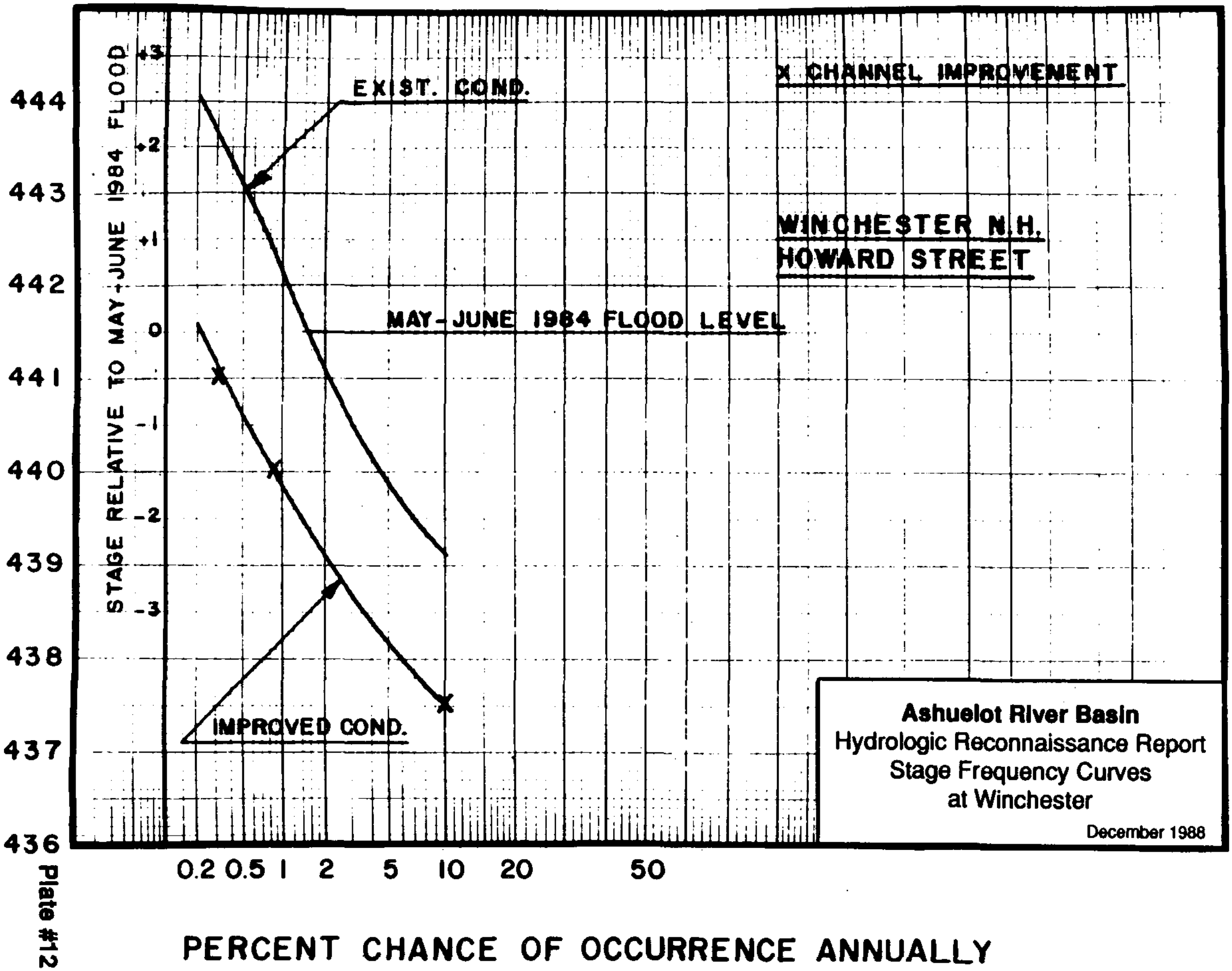
WINCHESTER, NH

PROFILE

HES 1988

PLATE 10


CHANNEL IMPROVEMENT
BOTTOM WIDTH 25 FT. MIN.
400 FT.
RT. 101
DAM
WATER ST.
DAM
100 YR EXIST. COND.
100 YR IMPROVED COND.
CHANNEL IMPROVEMENT
AVG. EXCAVATION = 3 FT
BOTTOM WIDTH = 20 FT. MIN.
700 FT.
100 YR. EXIST. COND.
100 YR. IMPROVED COND.
EAST TERRACE ST.
STATE ROUTE 101 (MAIN STREET)
IMPROVED CHANNEL INVERT
ELEVATION IN FEET (NGVD)
760
750
740
730
720
710
700
690
680
670
9.0
9.5
10.0
10.5
11.0
11.5
12.0
12.5
13.0
13.5
14.0
STREAM DISTANCE IN THOUSANDS OF FEET ABOVE CONFLUENCE WITH OTTER BROOK
MINNEWAWA BROOK
MARLBOROUGH, NH
PROFILES AT
RT. 101 & WATER ST
HES
1988
PLATE 11



Ashuelot River Basin
Hydrologic Reconnaissance Report
Stage Frequency Curves
at Winchester

December 1988

Plate #12

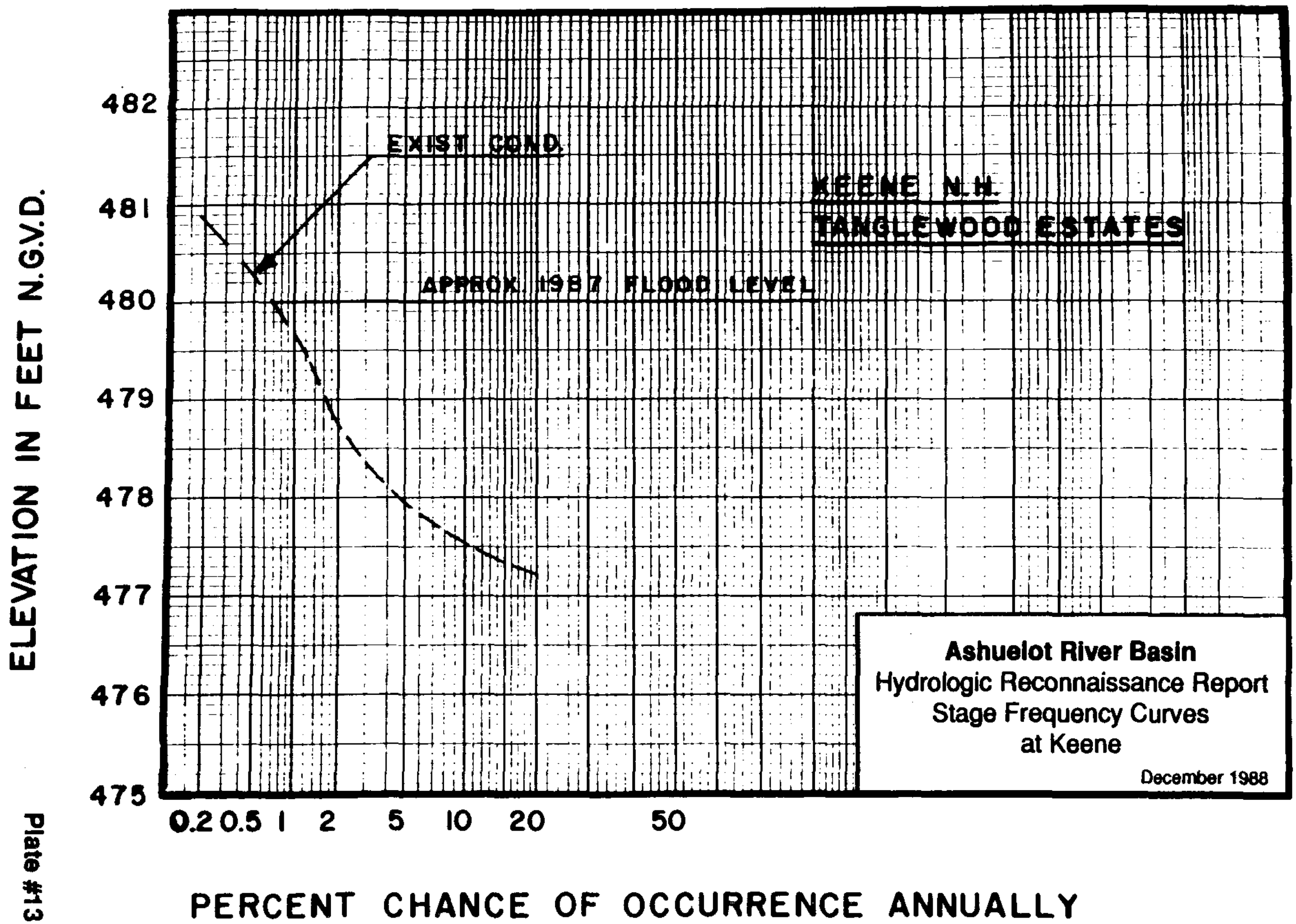

ELEVATION IN FEET N.G.V.D.
482
481
480
479
478
477
476
475
EXIST. COND.
APPROX. 1987 FLOOD LEVEL
KEENE N.H.
TANGLEWOOD ESTATES
0.2
0.5
1
2
5
10
20
50
PERCENT CHANCE OF OCCURRENCE ANNUALLY
Ashuelot River Basin
Hydrologic Reconnaissance Report
Stage Frequency Curves
at Keene
December 1988

Plate #13

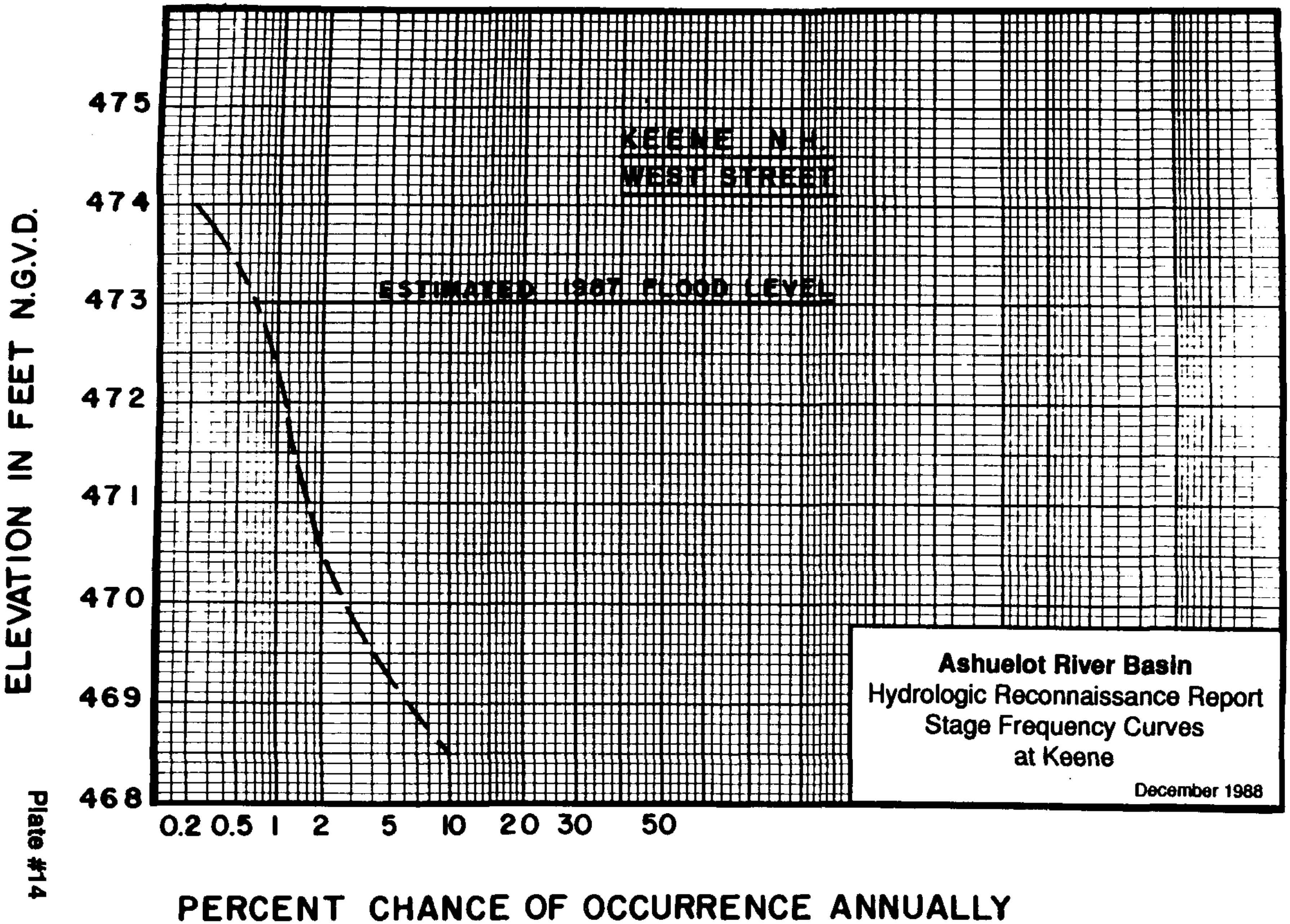
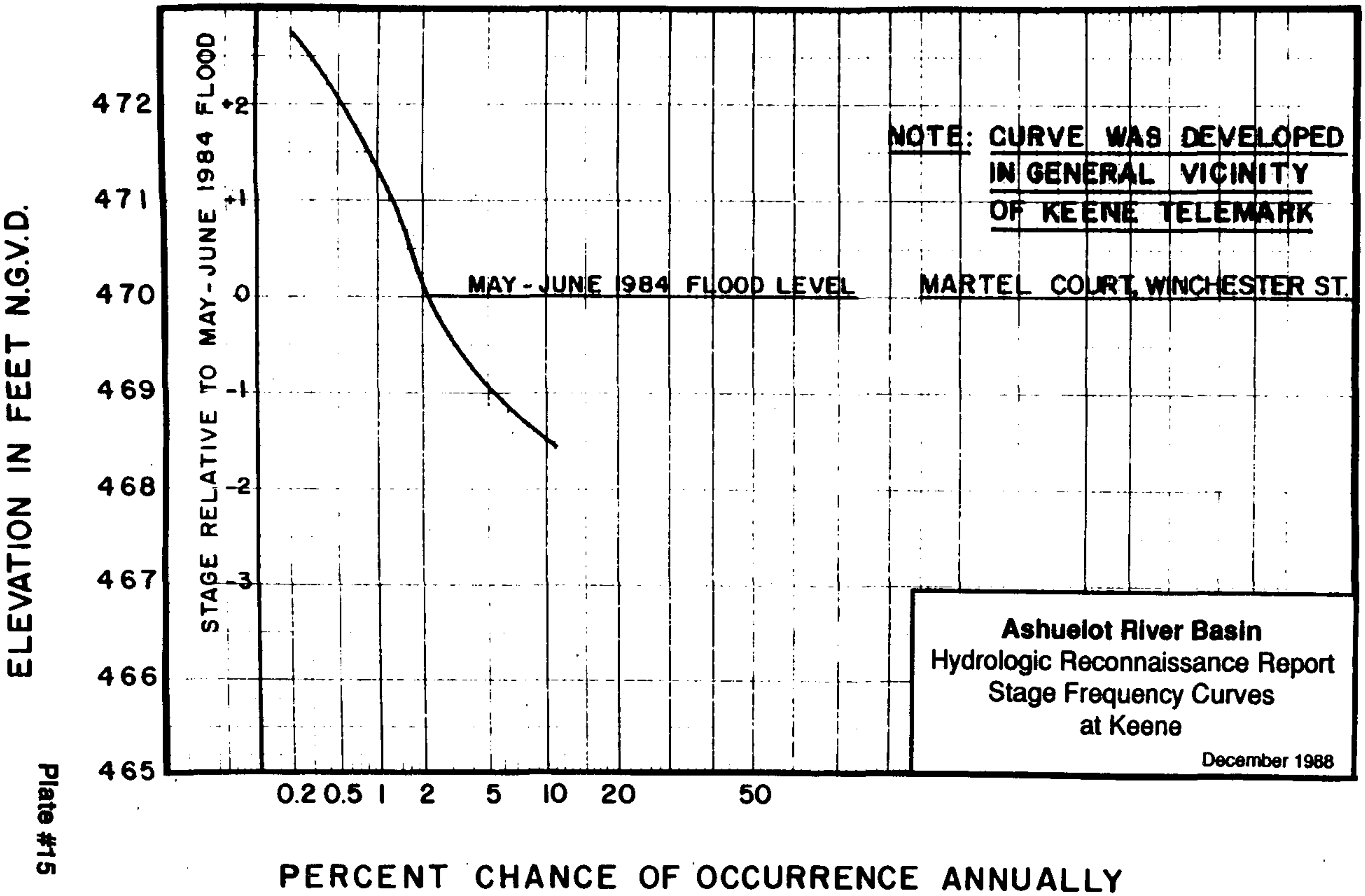

ELEVATION IN FEET N.G.V.D.
475
474
473
472
471
470
469
468
KEENE N.H.
WEST STREET
ESTIMATED 1987 FLOOD LEVEL
0.2
0.5
1
2
5
10
20
30
50
PERCENT CHANCE OF OCCURRENCE ANNUALLY
Ashuelot River Basin
Hydrologic Reconnaissance Report
Stage Frequency Curves
at Keene
December 1988

Plate #14



Ashuelot River Basin
Hydrologic Reconnaissance Report
Stage Frequency Curves
at Keene

December 1988

Plate #15

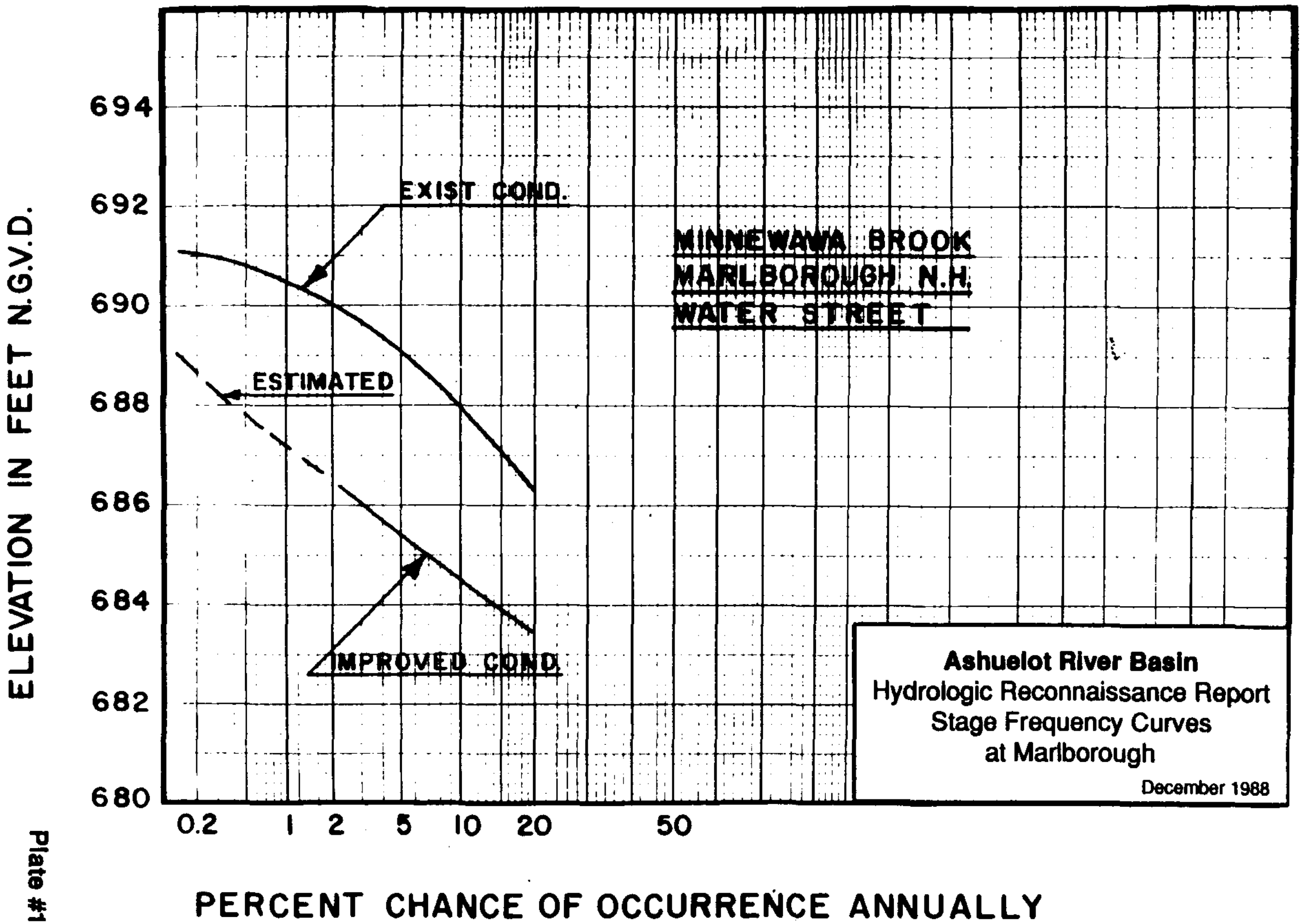
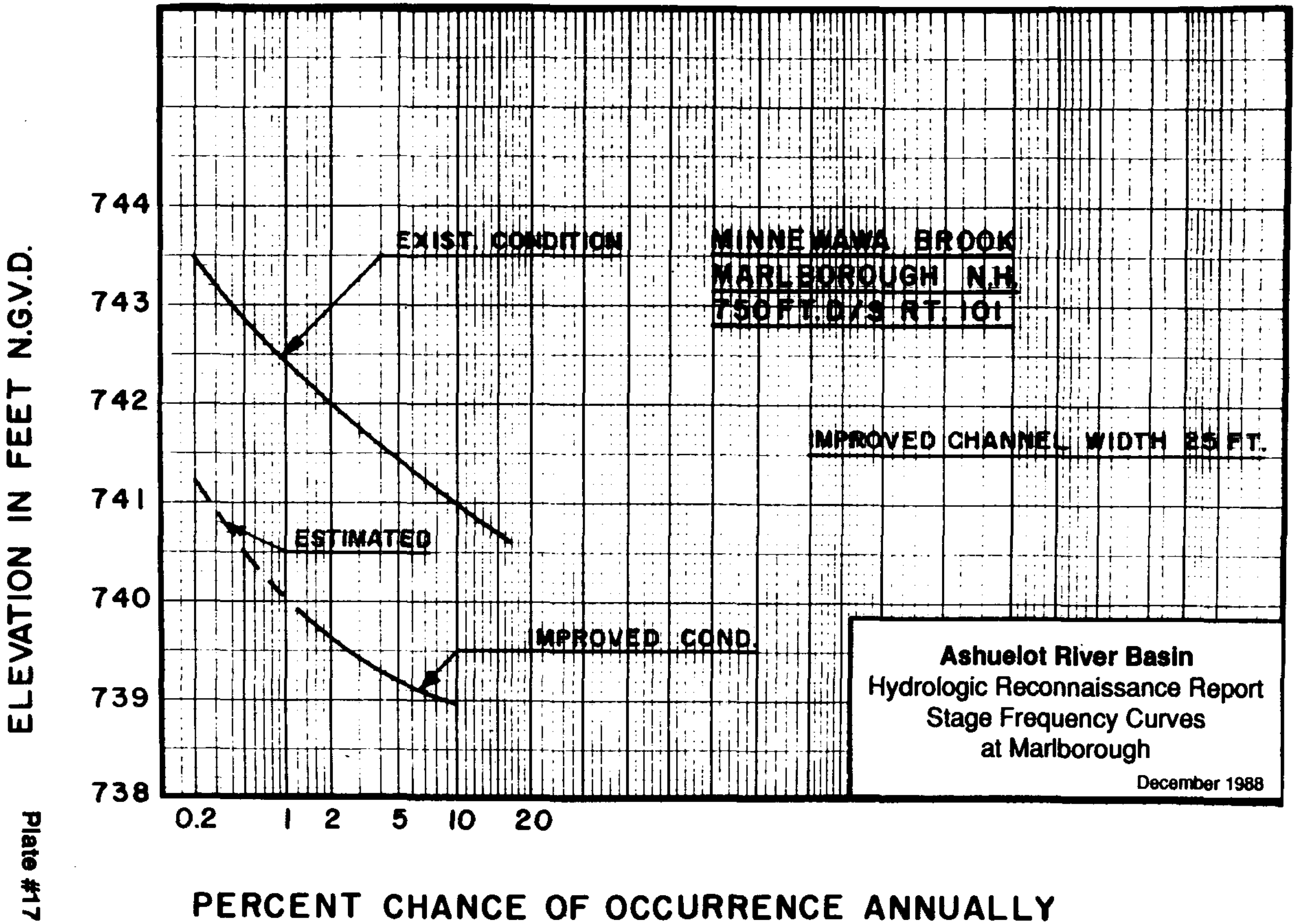

ELEVATION IN FEET N.G.V.D.
694
692
690
688
686
684
682
680
0.2
1
2
5
10
20
50
PERCENT CHANCE OF OCCURRENCE ANNUALLY
EXIST COND.
ESTIMATED
IMPROVED COND.
MINNEWAWA BROOK
MARLBOROUGH N.H.
WATER STREET
Ashuelot River Basin
Hydrologic Reconnaissance Report
Stage Frequency Curves
at Marlborough
December 1988

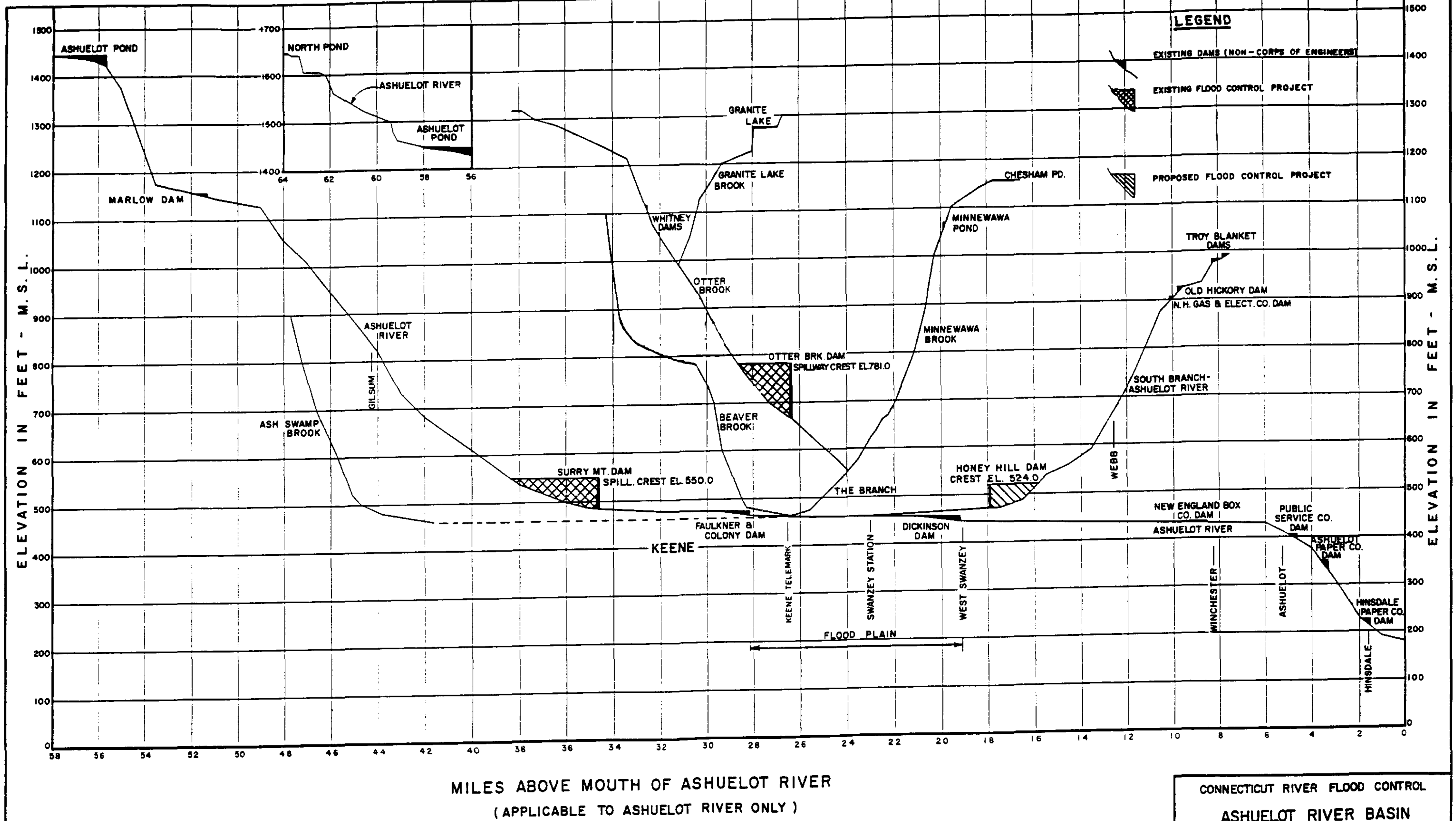
Plate #16



Ashuelot River Basin
Hydrologic Reconnaissance Report
Stage Frequency Curves
at Marlborough

December 1988

Plate #17



CONNECTICUT RIVER FLOOD CONTROL

ASHUELOT RIVER BASIN
PROFILES

ASHUELOT RIVER AND TRIBUTARIES

NEW ENGLAND DIVISION WALTHAM, MASS.
JUNE 1965

PLATE

APPENDIX A

CORRESPONDENCE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

Mr. Joseph Ignazio, Chief
Planning Division
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

9 1988

Dear Mr. Ignazio:

This planning aid letter is intended to provide a preliminary assessment of potential fish and wildlife impacts from several alternatives evaluated by the New England Division for the flood protection reconnaissance study of the Ashuelot River, Cheshire County, New Hampshire. It has been prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

PROPOSED FLOOD CONTROL MEASURES

The reconnaissance investigation encompasses several flood damage areas along the Ashuelot River and its tributaries, including sites in Keene, Marlboro, West Swanzy, and Winchester.

Three flood prone areas in Keene are addressed in this reconnaissance study. One of the areas is a municipal housing project off of River Street called Harper Acres. The only structural flood control option under consideration here is the construction of a levee/floodwall system to exclude flood waters. The second site in Keene is Tanglewild Estates, a mobile home park located along the Ashuelot River off of Court Street. As at Harper Acres, the only structural solution under consideration is the construction of levees and/or flood walls to exclude flood waters from the housing development. Non-structural measures such as floodproofing are also being considered for both sites. The third site in Keene involves a large flood-prone area near the intersection of Main Street and the highway 9-10-12 bypass. Flood prone structures here include a number of buildings in the Riverview Shopping Center as well as other commercial businesses in the area. Local protection plans involving levees or floodwalls would not be practical here due to the large area and number of major roadways involved. Therefore, the primary solution under consideration is the modification or possible removal of the West Swanzy Dam some nine miles downstream to reduce the backwater effect in Keene during flood events.

The West Swanzy site consists only of the West Swanzy dam near the Thompson Street bridge. Proposed improvements to the dam to alleviate upstream flooding originally involved installation of a tainter gate(s) in the dam crest. Opening the gate during flood events would reduce flooding upstream, but recent hydraulic studies showed that the maximum gate opening would only reduce water surface elevations some six miles upstream (the flood-prone area in Keene is approximately nine miles upstream). As an alternative, the possibility of removing the West Swanzy dam is currently being investigated. Additional hydraulic modeling will be necessary to determine if dam removal would appreciably reduce flooding upstream in Keene.

The Marlboro site on Minnewawa Brook includes two flood damage areas--one in the vicinity of the Water Street bridge and another upstream near the Route 101 bridge. The two structural measures under consideration for the Water Street site are minor channel modifications to increase channel capacity and construction of small berms or dikes to protect flood prone buildings. Channel widening has already been performed by the Town of Marlboro and additional hydraulic analysis should show if further widening would be justified. Dikes or berms would not be feasible at the Route 101 site due to the close proximity of buildings to the stream. Additional channel widening is the only structural alternative under consideration here.

Flood damage areas in the Town of Winchester encompass both the downtown vicinity to the east of the river and an area of residential and commercial development on the west side of the river adjacent to Hildreth Street. Again, the close proximity of buildings to the river would make the use of dikes or walls infeasible. The only structural flood control measure under consideration for Winchester is the construction of a bypass channel to divert a portion of flood flows around the town proper to reduce flooding. The bypass channel would likely originate at a new headworks structure on the west river bank in the pool formed by the existing but dilapidated "dam #4". A bypass channel, either grass or concrete lined, would carry up to 30 percent of flood flows (above a predetermined threshold) and discharge them back into the Ashuelot River downstream of the Route 119 bridge. Preliminary indications are that the channel would be approximately 5000 feet long. Final determination of the length and capacity of the channel will be dependent on more detailed hydraulic modeling studies.

Non-structural flood control measures are being considered for all study sites on the Ashuelot River. Non-structural flood control measures such as floodproofing buildings and relocation of flood-prone structures (depending on the site where the structures are relocated to) usually do not cause significant adverse impacts to fish and wildlife resources. Non-structural flood control measures are preferred by the Fish and Wildlife Service due to their low level intensity of adverse impacts.

HABITAT CHARACTERISTICS OF THE STUDY AREAS

The Ashuelot River, a tributary of the Connecticut River, drains a basin of approximately 420 square miles in southwestern New Hampshire. The Ashuelot River Basin contains several ponds and lakes, including two Corps of Engineers flood control reservoirs--Otter Brook and Surry Mountain. The watershed is hilly and primarily forested, with elevations ranging from the 3165-foot Mt. Monadnock to 200-feet msl at the confluence with the Connecticut River near Hinsdale. Elevations in the project areas range from 800 feet msl at Marlboro to 440 feet at Winchester.

Keene

The Harper Acres site in Keene includes three distinct cover types--manicured lawns, deciduous riparian forest, and palustrine wetlands. The manicured lawns have low habitat value as they are close cropped grass otherwise devoid of vegetation. Deciduous riparian forest is found between the river and the maintained grass areas and is quite dense. Tree species include red maple, red oak, gray and white birch, black cherry, and hemlock. The perimeter of the palustrine wetland is vegetated with blueberry, alder, european buckthorn, buttonbush, wild-raisin, arrowwood, spirea, and cinnamon fern. The palustrine wetland is an oxbow pond, approximately 2 acres in size, formed by an old meander bend of the Ashuelot River. Although separated from the river during low flow conditions by a natural vegetated berm, it appears that both the pond and the surrounding woodlands are regularly flooded during high flow conditions. In addition to the shrubby species described above, wetland plants found in the pond include pond lilies, pickerel weed, sedges and some cattails.

The Tanglewild Estates site is similar to Harper Acres in that it too has a dense band of deciduous riparian forest between the housing development and the Ashuelot River. This riparian border varies from 5 to 50 feet wide and runs the full length of the development. Tree species include: red and silver maple, black cherry, white and gray birch, ironwood, basswood, beech, slippery elm, red oak, white pine, eastern hemlock and American yew. Under story vegetation consists primarily of dense red-osier dogwood growth, but also includes alder, european buckthorn, spirea, and smooth sumac. Ground cover species include nettles, wood sorrel, poison ivy, ground ivy, Virginia creeper, checkerberry, grape, cinquefoil, sensitive fern, cardinal flower, and lambkill. Arrowhead, willow-herb, sedges, and rushes were among the wetland plants found along the river's edge.

The study site in Keene that includes the Riverview Shopping Center is extensively developed and offers little in the way of fish and wildlife habitat. No physical changes are expected here since flood control measures would be effected downstream at West Swanzy.

West Swanzy

The dam site in West Swanzy is adjacent to a medical supply company on the west bank of the Ashuelot River. Building foundations extend to the waters edge both up- and downstream of the dam. The east bank of the river has been extensively disturbed and vegetation is sparse, dominated by pioneering plants such as sumac and japanese knotweed. Other species present include choke cherry, big-tooth aspen, catalpa, silver maple, elm, european buckthorn, honeysuckle, milkweed, clover, and goldenrod. An unpaved access road leading to parking areas for fishing and dam access receives enough use to keep the vegetation here in early successional stages.

Marlboro

The Water Street study site on Minnewawa Brook in Marlboro extends approximately 750 feet downstream from the Water Street bridge and encompasses several flood prone businesses situated immediately adjacent to the brook on the southwest side. The uplands along the brook have been disturbed in the past and as a result, vegetative cover is limited. There is a narrow band of sumac, white ash, and sugar maple trees between the brook and the above-mentioned businesses that provide some shade, but no overhanging stream cover. The ground cover here is primarily grape, raspberry, and poison ivy. Streamside vegetative cover is lacking as a result of the recent (i.e. 1987) channelization work performed by the Town of Marlboro. Any previously existing streamside vegetation was covered with unconsolidated streambed material pushed up on the stream banks. In contrast, the undisturbed reach upstream of the Water Street bridge contains lush overhead cover, streamside vegetation, and a wetland sedge fringe.

The Route 101 study site in Marlboro encompasses a number of businesses that lie between Minnewawa Brook and Route 101, approximately 400 feet downstream of the Route 101 bridge. As at the Water Street bridge site, streamside vegetation was eliminated as a result of Marlboro's channelization work. Except for the ornamental plants at the Cheshire Floral Farm, there is no vegetation on the north side of the brook—the stream bank is covered with rubble, and borders parking lots and building foundations along the study site. The stream bank on the south side of Minnewawa Brook is steep and also is covered with a layer of unconsolidated rubble. Above this unvegetated zone there is an extensive stand of mixed deciduous/coniferous forest. Overstory species here include red maple, red oak, eastern hemlock, sugar maple, white pine, basswood, black cherry, and white birch. Understory plants include willow, alder, honey suckle, and gray birch. Goldenrod, cinnamon fern, raspberry, and asters are among the ground cover plants.

Winchester

The Winchester study site, both downtown and adjacent to Hildreth Street, is characterized by residential and commercial development. The riverbanks have been extensively impacted by human activities and buildings have been constructed right up to the rivers edge. A well developed riparian zone is lacking, however, there are a number of large silver maple trees along both sides of the river that provide overhead shade. Those portions of the river banks that are not covered by building foundations support grasses and vine species such as grape and raspberry. The river bank in the vicinity of the proposed bypass channel headworks contains a few shrubs that provide limited shade and cover. The bypass channel would follow an old railroad bed for almost the entire 5000-foot length. The tracks have recently been removed from the right-of-way and there is currently no vegetation for most of its length. Off-road vehicle use was observed along the right-of-way which will likely preclude vegetative cover from becoming established.

WILDLIFE RESOURCES

Keene

Both the Harper Acres and Tanglewild Estates study sites provide excellent fish and wildlife habitat in an otherwise urban setting in Keene. The dense riparian forest offers high quality nesting, foraging and hiding cover for small mammals and birds. It also serves as an important buffer between the housing developments and adjacent wetlands, filtering urban runoff and acting as an audio-visual barrier. The oxbow pond, with its well developed aquatic plant community and seasonal connection with the Ashuelot River, probably serves as an important off-channel refuge for juvenile and adult fish. This wetland also provides excellent nesting and brood habitat for waterfowl such as wood duck, black duck, and mallard as well as other mammal, reptile , and amphibian species.

West Swanzy

Habitat value in the vicinity of the West Swanzy Dam abutments is low due to the disturbed nature of the site, proximity of buildings and human activity, and lack of vegetation. Wildlife use is probably limited to birds and small mammals feeding on seeds and fruits.

Marlboro

Habitat value at the Water Street site is low due to the lack of vegetative cover and close proximity to buildings and human activity. Wildlife habitat at the Route 101 site is good by comparison, since the south bank of Minnewawa Brook is undeveloped and contains relatively mature stand of deciduous and coniferous trees with a well developed understory.

Winchester

Overall, fish and wildlife habitat value is fair to low at all of the areas potentially affected by construction of a bypass channel through Winchester. The small area of shrub cover on the west bank in the vicinity of the proposed canal headworks offers moderate quality feeding and nesting habitat for passerine birds, but is quite limited in extent. Aquatic habitat consists of large pools and slow glides and instream cover diversity appears to be low.

Bird species observed at the Ashuelot River study sites include: belted kingfisher, spotted sandpiper, great blue heron, catbird, Northern oriole, red-winged blackbird, American robin, cardinal, bluejay, mourning dove, goldfinch, starling, and house sparrow. Other common species that could be expected to use the site would include woodpeckers (hairy, downy, flicker), yellow and other warblers, thrushes, eastern kingbird, black-capped chickadee, song sparrow, and kestrel. Mallard, black duck, wood duck, and merganser are among the waterfowl that may utilize wetland habitats in the study areas. Woodcock probe holes were observed in the soft mud along the river at the Court Street site in Keene.

Wildlife sign observed at the study sites included that of beaver, muskrat, and raccoon. Red squirrels were observed at the Winchester site while eastern gray squirrels were seen at Keene and Marlboro. Other animals such as striped skunk, porcupine, woodchuck, New England cottontail, snowshoe hare, and opossum could likely be found at all of the study sites as could small mammals like the deer mouse, jumping mouse, masked shrew, water shrew, flying squirrel, and several bat species. Water-oriented species such as beaver, muskrat, mink, otter could be found at any of the sites. Other mammals like the red fox, long-tailed weasel, and white-tailed deer are also potential inhabitants of the project sites.

THREATENED AND ENDANGERED SPECIES

On August 22, 1988, we provided a list of threatened and endangered species to the Planning Division for this and several other reconnaissance investigations. The presence of the dwarf wedged mussel, a candidate species soon to be proposed as endangered, was noted in the Ashuelot River below Surry Dam. Surveys of the Ashuelot River Basin for the dwarf wedged mussel are needed. We encourage your continued coordination with this office throughout the planning process for information on survey requirements and the listing status of this species.

FISHERY RESOURCES

Aquatic habitat in the study areas varies widely. The Harper Acres site in Keene is a backwater slough with extensive aquatic plant growth that offers good habitat for warm water species, particularly juvenile life stages. The Tanglewild Estates site in Keene has large pools and glides, with lots of large organic debris in the channel that provides excellent cover for fish. Largemouth bass, sunfish, and suckers were seen in this reach during our site visit.

At West Swanzy, the impoundment created by the dam forms a pool with fine grained substrate and little instream cover. Below the dam there is a wide scour hole with turbulent bubble cover from flow off the dam apron. This appears to be a popular local angling spot.

The Ashuelot River at Winchester is deep and slow, with dam #4 forming a backwater pool in the vicinity of the proposed bypass channel headworks. Substrate exposed along the river margins is primarily large cobble with fine sediment deposited in the interstices of the stones.

Aquatic habitat at both Marlboro sites has been seriously impacted by the recent channel modifications. Large organic debris, instream cover objects, and overhanging vegetation were for the most part eliminated. Pool-riffle complexes eliminated by the creation of a trapezoidal cross-section channel are slowly beginning to re-form as the streambed material is reworked by water in the channel. Although some stream shading is provided by deciduous upland trees at the Route 101 site, stream cover and shading is lacking in the reach below the Water Street bridge.

Fish species reported as occurring in the Ashuelot River include: American smelt, brook, brown and rainbow trout, white sucker, chub-sucker, black-nose and long-nose dace, fallfish, creek chub, common shiner, golden shiner, silvery minnow, smallmouth bass, largemouth bass, bluegill, red-breasted sunfish, yellow perch, johnny darter and slimy sculpin. Both brown and rainbow trout are planted annually in the Ashuelot River by the New Hampshire Department of Fish and Game. Brook trout were last planted in 1979.

Fish species that can be expected to occur in Minnewawa Brook would include brook trout, which were last planted by the New Hampshire Department of Fish and Game in 1973, brown bullhead, creek chub, fallfish, eastern black- and long-nosed dace, eastern johnny darter, and slimy sculpin.

Fishery management in the Ashuelot River will eventually be affected by the Connecticut River Atlantic Salmon Restoration Program. This is a cooperative state-federal effort, begun in 1967, to restore and maintain Atlantic salmon in the Connecticut River basin at levels sufficient to provide both natural spawning populations and a sport fishery. The Ashuelot River is not one of the initial ten high priority streams designated for restoration (deferred status). However, once the long-term goal of full watershed utilization is realized, fish passage will likely be required at the Ashuelot River dams. This would allow access to the project vicinity by not only Atlantic salmon, but also by the anadromous American shad.

POTENTIAL PROJECT IMPACTS

Channel Modification

Channel widening to increase channel capacity during flood conditions is proposed as a structural flood control alternative only at Marlboro. Direct impacts from channel widening could include direct mortality of fish and aquatic organisms, permanent habitat loss, and impacts to downstream habitat and water quality from construction-related sedimentation. Due to the level of habitat degradation the Marlboro study sites have recently incurred, additional channel widening and obstruction removal would probably not impact fish and wildlife habitat significantly if the work were performed in the next one or two years. However, as the stream begins to recover and habitat conditions improve over time, more severe impacts from additional channel modifications could be expected.

At the Route 101 site in Marlboro, channel widening along the south bank of Minnewawa Brook would eliminate a small strip of mixed deciduous/upland forest, resulting in the loss of bird and small mammal habitat and overhead shade cover. Turbidity and sedimentation would be a product of instream construction activities and would adversely affect downstream aquatic resources and habitat. Sediment production could be a long-term impact if the disturbed stream banks are not properly protected following construction.

It is possible that an environmentally sound streambank modification project at this site could provide long-term benefits to fishery resources in two ways. First, bank stabilization/revegetation could reduce erosion of the raw streambanks left exposed by the previous channel work. Second, development of a permanent flood control solution would presumably eliminate the chronic habitat disturbance associated with repeated channel dredging/widening by local entities.

A structural flood control project on Minnewawa Brook may also provide an opportunity to restore degraded instream habitat. This could be accomplished by the placement of instream structures to recreate pools and riffles, and by seeding grasses and planting hydrophytic shrubs along the stream banks to control erosion and provide shade, food and cover.

Levees and Flood Walls

Levees, berms and/or flood walls are being considered as structural flood protection alternatives at Keene and Marlboro. The primary impacts of levee and floodwall construction would be the direct physical loss of habitat from construction of the structures and construction-related impacts to habitat and water quality.

Construction of floodwalls and/or levees along the Ashuelot River at both the Harper Acres and Tanglewild Estates sites in Keene could eliminate high quality wetland and riparian habitat. Due to their close proximity to wetlands and riparian habitats, it is likely that dike or wall construction at either site would encroach upon these important habitat areas. Due to their high habitat value and the difficulty in developing successful mitigation, we would recommend against the construction of levees and floodwalls within these productive wetlands or streamside riparian buffers.

At the Water Street study site in Marlboro, a levee or smaller berm structure constructed along the south bank of Minnewawa Brook would have little impact to wildlife habitat since the area is already developed and has recently been disturbed. Efforts still should be taken to keep the structure out of the stream channel and to fully stabilize the slopes with vegetation to prevent erosion and downstream sedimentation.

In addition to direct habitat losses from construction of levees and floodwalls, wildlife utilizing adjacent habitats would be displaced during disruptive construction activities. Depending on the season and length of the construction period, temporary displacement may lead to direct mortality due to nest abandonment or dispersal-related losses (predation, competition, road kill, etc.). This disturbance factor would apply to all structural flood control measures. Although disturbance cannot be eliminated, mortality associated with nest failure can be reduced by scheduling all construction activities for the late summer and fall months.

The ordinarily severe impacts from either floodwall or levee construction can be substantially lessened if the structure is constructed well back from the waters edge and associated riparian buffer zone. Also, the use of floodwalls would have relatively less impact than levees due to their reduced physical coverage. We will need to review additional information on the actual siting of structures, physical extent of coverage, structure design, and construction techniques before we can fully evaluate the impact of levee or floodwall alternatives. Before mitigation measures can be developed, more detailed evaluations of the habitat value of affected areas for target species would have to be completed.

Bypass Channel

Construction of an overflow channel to divert flood flows around critical damage areas in Winchester could affect fish and wildlife resources in several ways. Habitat for upland wildlife species would be eliminated by the footprint of the overflow channel, however, the actual loss of habitat value would not be significant since the proposed alignment lies within the already disturbed railroad right-of-way and vegetation is sparse. It is unlikely that wetlands or other unique habitat types would be affected.

Conversion of the abandoned railroad right-of-way to a conveyance for seasonal flood flows could improve existing habitat values if the channel were unlined and wetland vegetation allowed to become established. Habitat values would be further improved if a vegetated buffer was maintained along the length of the channel. Wildlife habitat would not be improved if the channel were concrete lined.

Fishery resources would experience both positive and negative effects from bypass channel construction. Juvenile and adult fish may seek refuge in the bypass during high flow events. If the channel is designed with aquatic habitat features such as cover and holding pools, good refuge and rearing habitat may be provided. In order for the project to offer this type of aquatic habitat enhancement, a small amount of flow would have to be provided through the bypass channel at all times. If some flow cannot be maintained in the channel at all times, fish that moved in during high flows may experience mortality upon cessation of flow diversion as a result of predation, desiccation, and/or water quality degradation.

If the channel cannot be designed to enhance fish and wildlife habitat, then measures should be provided to prevent fish from becoming injured or stranded upon passing through it. The channel floor should be smooth to prevent abrasion, and should contain no irregularities that would pond water and thus trap fish when the channel is dewatered.

Given the existing management goals to restore anadromous fish species in the Connecticut River Basin, the project should be designed to protect anadromous species or to permit easy retrofitting of protective measures once fish are present. The primary concern with anadromous species would be to assure that neither juveniles or adult migrants become trapped in the channel when it is dewatered. This could be accomplished either by designing the channel to allow fish to escape as flows are gradually reduced, or to exclude them from the channel with screening or some other means.

Fish stranding may occur in the Ashuelot River bypassed reach if up to 30 percent of the river flow is suddenly diverted into the bypass channel all at once. A gradual gate opening rate will have to be established empirically to prevent rapid stage drops that may strand fish during flood flow diversion.

Channel morphology in the Ashuelot River may be affected if the occurrence interval of flushing flows that move bedload and cleanse the gravel are reduced appreciably by diverting high flows. Additional investigations of channel hydraulics and sediment transport should be performed to assess the affect of flood flow diversion on channel morphology and aquatic habitat.

Dam Modification/Removal

The addition of tainter gates to the West Swanzy dam should have little impact on wildlife resources since the construction and staging areas are already disturbed. Impacts to fish and other aquatic resources depend on how the gates are constructed and operated. Water quality could be adversely affected by sediment and possibly contaminants associated with sediment unless equipment is properly isolated from flowing water and effective erosion control measures are implemented.

Complete removal of the dam could have more serious impacts than adding tainter gates. Extensive areas of palustrine and riverine wetlands along the river upstream of the dam would likely be affected by the reduction of water surface elevations associated with dam removal. It is also likely that ground water levels would be reduced, which could dry up isolated wetlands in the Ashuelot River valley that are not directly connected to the river. Sediments accumulated behind the dam would be flushed downstream. The river bed would erode until a new equilibrium is reached.

If the option of dam removal is pursued further, additional impact analyses will be needed. Physical and chemical analyses of sediments accumulated behind the dam should be performed to evaluate potential impacts to water quality and aquatic life. An evaluation of channel dynamics would be necessary to determine impacts to fishery habitat both up-and downstream of the project. Ground water and river hydraulic studies should be completed to determine how changes in water levels would affect wetlands. Detailed surveys of wetlands in the Ashuelot River valley between West Swanzy and Keene should also be performed during the detailed project review.

Given the long term fishery management goal of anadromous fish restoration in the Connecticut River Basin, we recommend that any modifications to the West Swanzy Dam also include fish passage facilities. Fish passage may be made possible without constructing fishways if the dam is removed. Specific fish passage design considerations should be evaluated during the detailed project review.

Nonstructural Measures

The prevention of flood damages through the use of nonstructural measures such as flood proofing and structure relocation would, for the most part, not impact the fish and wildlife resources of the Ashuelot River. The only possibility of habitat degradation from nonstructural measures would be if houses or other structures were relocated to areas currently occupied by wetlands or other wildlife habitat areas that are currently undeveloped.

Summary

All of the structural alternatives for flood control in the Ashuelot River study area have the potential to cause adverse impacts to important fish and wildlife resources. We recommend that nonstructural measures be used where possible to accomplish flood control objectives on the Ashuelot River because they offer a solution that is essentially free of impacts to natural environmental features.

The use of levees or floodwalls at the Ashuelot River study sites may impact important wetlands and riparian habitat, particularly at Harper Acres and Tanglewild Estates. Additional impact evaluations will be necessary when specific project details are developed. Design considerations for levees and walls should include: 1) adequate setback from the riverbanks; 2) avoidance of wetlands; and 3) maintenance of the full width of existing riparian zones.

The addition of tainter gate(s) to the West Swanzy Dam should have little direct impact on fish and wildlife habitat provided that construction techniques which prevent water quality degradation are used. Complete removal of the dam may be beneficial for fish passage, but also may have significant impacts to wetlands and other habitat types from lowering water levels. Impacts to fish habitat from changes in riverbed morphology and sediment releases could also be expected. Studies on hydraulic and ground water changes, sediment characteristics and transport, and channel morphology will be necessary before we can fully evaluate the impact of dam removal. Field surveys of wetlands potentially affected by dam removal should be included in future project investigations. Also, we recommend that future design studies for the project include an evaluation of fish passage at the dam site to further the goal of anadromous fish restoration in the Connecticut River Basin.

Depending on when the work is accomplished, minor channel widening at both Minnewawa Brook sites in Marlboro may be possible with only minor impacts to fish and wildlife resources since both areas have been previously disturbed. As the stream begins to recover over time, project impacts may become more severe. Review of specific project plans will be necessary before we can fully evaluate impacts to fish and wildlife. Additional habitat surveys to evaluate current conditions at the study sites should be repeated periodically as the planning process continues. Also, we recommend that mitigative and restorative measures to improve degraded habitat conditions in Minnewawa Brook be investigated during the detailed project review.

It is possible that a flood flow bypass channel could be constructed and operated at Winchester with minimal impacts to fish and wildlife resources. However, studies are needed to determine the effect of flow diversion on biota and habitat conditions in the bypass reach; to develop mitigative measures to prevent fish injury and stranding during operation of the bypass; and to evaluate wildlife habitat conditions along the actual project alignment once it is formally identified. Future project investigations should address the possibility of incorporating habitat enhancement measures into the channel design such as utilizing an oversized natural channel bottom and allowing the establishment of wetland vegetation.

We hope you and your staff find this planning aid letter useful for your reconnaissance study. Please feel free to contact Michael Tehan of my staff at 603-225-1411 or FTS 834-4411 if there are any questions regarding these comments.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Area

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION I

J.F. KENNEDY FEDERAL BUILDING, BOSTON, MASSACHUSETTS 02203-2211

November 3, 1988

Mr. Joseph L. Ignazio, Chief
Planning Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

Dear Mr. Ignazio:

Thank you for the opportunity to comment on your reconnaissance study to examine flood damage reduction measures for flood prone areas of the Ashuelot River in Keene, Swanzey, Marlboro and Winchester, New Hampshire. EPA has not seen the sites which are being reviewed for structural and non-structural changes, nor have we reviewed any documents. Therefore, our comments are partly general in nature. Judy Johnson of your staff has provided us with information about some of the options you are considering and we will attempt to provide a response to them.

We are encouraged by the non-structural investigations of your study. Floodproofing structures, raising structures, and flood warnings and evacuation all have a minimal impact on the aquatic environment compared to the structural options discussed below. These options are usually the least environmentally damaging alternatives to satisfy the basic project purpose. Acquiring floodplain habitat to prevent flooding would also comply with the EPA 404 (b)(1) Guidelines.

EPA generally does not support structural methods to decrease flood damage if structural options will cause impacts to the aquatic environment by altering the riparian habitat. Structural methods often fill wetlands and indirectly alter other wetlands by disrupting the floodplain hydrology. Removing the forested buffer zone along rivers usually destroys the wildlife cover and restricts animal movement patterns. It also removes shade trees along the bank which help protect the cold water fisheries in the river. However, each proposed action will require site specific information before an informed decision can be reached.

The structural option being considered in Keene is constructing a floodwall/levee adjacent to the river. This would probably remove palustrine wetlands and riparian forest habitat, which act as an important buffer for wildlife and protect and maintain water quality in the river. EPA recommends against such an action and supports nonstructural approaches instead.

In West Swanzey, the Corps is considering modifying the tainter gates on the dam near Thompson Street Bridge. If the dam can release more water during flood events, it is thought that it might reduce the flooding upstream in Keene. This a structural change which EPA probably can support; however, it is unclear whether this project will accomplish what it intends. The dam is nine miles downstream from major flooding sections of Keene, and additional hydrological studies are needed to understand if the dam will reduce flooding nine miles upstream.

In Marlboro, the Corps is considering widening the channel of the Minnewawa Brook in two locations. Our recommendations for these projects depend on the habitat being lost. We understand that the Route 101 site contains a mature forest adjacent to the river. Since it provides shade, wildlife habitat, and a buffer zone for non-point source pollutants, we recommend not altering it. The Water Street site apparently supports low quality habitat, but part of this is due to recent channelization performed by the Town of Marlboro. The Corps enforcement section needs to complete its work, and EPA will comment further, if this option moves forward, after we visit the site.

In Winchester, the riverbank has been heavily impacted by human activities and provides little habitat value. The structural option being considered is diverting some portion of the stream, when the water reaches a certain level, to a different route. This proposed channel would replace an abandoned railroad track and flow back into the river 5000' downstream. Much more information is needed before EPA can comment on this project. It has the potential to provide better overall habitat value, but the channel must not be concrete lined, some flow must be maintained to support aquatic life, and the adjacent upland should be stabilized with a vegetative cover. We will be happy to comment in greater detail if this project receives further consideration, after we complete a site visit.

We hope that floodplains along the Ashuelot River and its tributaries can be protected by natural valley storage. We encourage the Corps to consider floodplain acquisition as a environmentally sound option to help prevent even more flooding problems in the future. Those towns which have allowed its floodplain to be filled and choose to allow further development in the floodplain contribute to the present and future flooding problems. Structural methods being considered to replace this lack of long-term planning should not adversely impact the environment.

In summary, some structural options need further information, but EPA prefers the non-structural methods. Please contact Mark Kern at 565-4426 for further coordination on this project.

Sincerely,

Douglas A. Thompson, Chief
Wetlands Protection Section

cc: see following page

cc: M. Tehan, FWS, Concord, NH
J. Johnson, Corps
K. Kettenring, NH Wetlands Board
R. Manfredonia, EPA, WQB-2103
B. Higgins, EPA, RGR-2203

State of New Hampshire
Fish and Game Department

2 Hazen Drive, Concord, NH 03301
(603) 271-3421

Donald A. Normandeau, Ph.D
Executive Director

September 21, 1988

Joseph Ignazio, Chief
Planning Division
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham MA 02254

Dear Mr. Ignazio:

The following are the preliminary comments by the New Hampshire Fish and Game Department regarding anticipated impacts to the fish and wildlife resources from the several alternatives for flood protection in the Ashuelot River watershed. The Department is providing comments pursuant to the Fish and Wildlife Coordination Act (48 Stat.401 as amended; 16 U.S.C. 661 et seq.) and NH RSA 206:9 and 206:10.

Flood damage areas in three towns were investigated by your agency. In Keene three areas were studied. One site is a municipal housing project off River Street. One of studied the options is to construct a flood wall to prevent flood waters from reaching the housing project. Between the housing project an the Ashuelot River is a 2 acre marsh which provides valuable habitat for several species of fish and wildlife. Any structures must be designed to avoid any impacts to this wetland. The department also recommends that your agency look into the operation of the flood gates of a dam on the river which is within a mile of this study area. The operation of flood gates during flood events may eliminate the need for any flood control structures.

Another area in Keene under investigation for possible construction of a flood wall is in Tanglewild Estates. The wall would be constructed between the mobile homes and the river. The department recommends that other less damaging alternatives be investigated as any flood wall would require substantial disturbance of stable river bank and the loss of riparian habitats for several species of fish and wildlife.

Another damage site is in the Town of Winchester. Your agency is investigating the construction of a 5000' flood bypass channel which would carry up to 30 percent of flood flows of the Ashuelot River around flood prone areas. If this alternative is pursued this department does not foresee any adverse impacts to fish and wildlife provided that wetlands are avoided and the channel is planted to grass or allowed to grow into shrubs and not lined with concrete.

Two damage sites in the Town of Marlboro along Minnewawa Brook are being investigated for possible structural measures. One site at the Water Street Bridge is being investigated for the possible removal of an obsolete dam and the construction of a flood wall between the brook and an industry. Both of these proposed structural measures should have little impact on fish and wildlife. Stringent measures must be taken to control turbidity during the removal of the dam.

The other site is adjacent to Route 101 and a small shopping mall. The proposed structural alternative calls for widening of the brook channel to accommodate flood flows. If this alternative is pursued it is recommended that actual construction not occur in the existing stream bed but that excavation be undertaken on the opposite bank of the brook from the shopping mall. Such excavation would provide a flood relief channel and at the same time not impact the existing fisheries habitat in the brook.

Another site is in the Town of Swanzey at the site of the West Swanzey Dam. It is proposed that a flood gate be installed and operated during flood events to alleviate damage upstream. This proposal would have little impact on fish and wildlife and would assure the continued protection of the extensive wetlands along the Ashuelot River upstream of the dam.

As previously stated these comments by this department are preliminary. Formal comments and recommendations for compensation or mitigation of fish and wildlife habitat losses will be provided when your agency provides this department with a final flood control plan for the Ashuelot River watershed.

If you have any questions please contact Fisheries and Wildlife Ecologist, William Ingham, Jr. at (603) 271-2501.

Sincerely,

Donald A. Normandeau, Ph.D.
Executive Director

DAN/WCI
cc: William Ingham, Jr.
Gordon Beckett

State of New Hampshire
DEPARTMENT OF ENVIRONMENTAL SERVICES
WATER RESOURCES DIVISION
64 North Main Street
Post Office Box 2008
Concord, NH 03301-2008
603-271-3406

ALDEN H. HOWARD
COMMISSIONER
DELBERT F. DOWNING
DIRECTOR

June 27, 1989

Mr. Joseph L. Ignazio
Chief, Planning Division
New England Division Corps of Engineer
424 Trapelo Road
Waltham, MA 02254-9149

Dear Mr. Ignazio:

Our office has reviewed the Water Resources Study draft report on the Ashuelot River Basin prepared by U.S. Army Corps of Engineers, New England Division.

As your report indicates only one community of the five in the study area has justification to economically proceed with a channel modification project, but must proceed under Section 205 of the Flood Control Act of 1948.

Hopefully the local community will avail themselves of the opportunity with the other entities that experience flooding conditions along the Ashuelot River implement the suggested non structural protective measures outlined in the report.

The N.H. Water Resources Division has no reported changes or additions to the report and concurs with the findings and recommendations.

Respectfully yours,

Delbert F. Downing By MK

Delbert F. Downing
Director

DFD/DMR/nll

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION I

J.F. KENNEDY FEDERAL BUILDING, BOSTON, MASSACHUSETTS 02203-2211

July 12, 1989

Mr. Joseph L. Ignazio, Chief
Planning Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

Dear Mr. Ignazio:

Thank you for the opportunity to comment on your Water Resources Study to examine flood damage reduction measures for flood prone areas of the Ashuelot River in Keene, Swanzey, Marlborough and Winchester, New Hampshire. Due to staffing constraints, EPA was unable to visit any of the sites the Corps invited us to inspect. Therefore, our comments are partly general in nature.

The report indicates that flooding problems in the greater Keene valley are severe and will get worse in future years if towns continue to fill in wetlands and other natural floodwater storage areas. Keene and other adjacent towns, the report suggests, should adopt zoning or compensatory storage requirements to prevent any further losses. The report also indicates that the Corps will not recommend any structural alternatives under the General Investigation program because they were not economically justified. One small structural alternative was found to be cost effective -- a channel modification in Marlborough; however, it had a low implementation cost and the Corps will not be recommending it.

In Marlborough, the Corps examined widening the channel of the Minnewawa Brook in two locations. We understand that the Route 101 site contains a mature forest adjacent to the river. Since it provides shade, wildlife habitat, and a buffer zone for non-point source pollutants, we recommend not altering it. The Water Street site apparently supports low quality habitat, but part of this is due to recent unauthorized channelization performed by the Town of Marlborough. The Corps enforcement section needs to complete its work, and EPA will comment further, if this option moves forward, after we visit the site.

Non-structural investigations, such as floodproofing structures, raising structures, and flood warnings and evacuation, have a minimal impact on the aquatic environment compared to the structural options the Corps reviewed. These options are usually the least environmentally damaging alternatives to satisfy the basic project purpose. Acquiring floodplain habitat to prevent flooding is also something EPA would support.

We hope that floodplains along the Ashuelot River and its tributaries can be protected by natural valley storage. We encourage the Corps to consider floodplain acquisition as a environmentally sound option to help prevent even more flooding problems in the future. Perhaps the towns suffering damage from flooding can economically support the acquisition, thereby making it more cost effective for the Corps to pursue.

Structural methods of reducing flooding often fill wetlands and indirectly alter other wetlands by disrupting the floodplain hydrology. Removing the forested buffer zone along rivers usually destroys the wildlife cover and restricts animal movement patterns. It also removes shade trees along the bank which help protect the cold water fisheries in the river. We cannot support flood control projects that cause considerable environmental damage when towns continue to allow wetlands and floodplains to be filled. EPA strongly endorses your recommendation to Keene and nearby towns to pass zoning requirements to prohibit wetland and other flood storage losses.

In summary, we support the Corps recommendations that no structural alternatives for flood control be pursued and that the towns adopt strict zoning to protect their remaining wetlands and other floodstorage areas. Please contact Mark Kern at 565-4426 for further coordination on this project.

Sincerely,

Ronald Manfredonia, Chief
Water Quality Branch

cc: M. Tehan, FWS, Concord, NH
J. Johnson, Corps
K. Kettenring, NH Wetlands Board
B. Higgins, EPA, RGR-2203
E. Thomas, FEMA, Boston, MA

APPENDIX B

ECONOMIC ANALYSIS

ECONOMIC ANALYSIS

Introduction

The purpose of the economics section is threefold. The first is the specification of the flood loss potential as it relates to the existing without project condition in the Ashuelot River Basin. This is accomplished by delineating significant flood damage centers, identifying floodplain activities and estimating recurring losses and expected annual losses. Secondly, inundation reduction benefits are estimated for structural and nonstructural improvement plans. Thirdly, each plan's measure of economic justification are determined through calculation of a benefit cost ratio. Net benefits for each plan are also presented. Annual losses and benefits reflect the October 1988 level of prices.

Overall Study Area

Based on problem identification efforts of the project manager and project team, the following areas in the Ashuelot River Basin were identified as having existing flood loss potential and required focused study: (i) Marlborough, N.H. (Minnewawa Brook), (ii) Keene, N.H. (Ashuelot River and Ash Swamp Brook) and (iii) Winchester, N.H. (Ashuelot River).

Flood Damage Survey

A flood damage survey was performed in Marlborough, Keene and Winchester, N.H. during May and June 1988 by an NED damage evaluator. Flood related losses were estimated for each floodprone structure and site beginning at the elevation at which discernable losses and damages are first incurred up to the flood elevation of a rare and infrequent (500 year) event. The reference point at each structure was the first floor elevation. Ground and first floor elevations for most properties were obtained. Interviews were conducted for commercial, industrial and public activities. For residential properties, use of sampling, typical loss profiles by type of house and minimal interviewing were employed. Both physical and non-physical losses were estimated. Also, the cost of emergency services and damages to transportation, communication and utility systems were obtained where possible.

Recurring Losses

Recurring losses are those potential flood related losses which are expected to occur at various stages of flooding under present day development conditions. As the final output of the flood damage survey process, recurring losses are expressed as an array of dollar losses, in one foot increments, from the start of damage to the elevation of the rare (500 year) event. Total recurring losses for selected events in the 3 basin towns under study are displayed in Table B-1.

Table B-1

Recurring Losses

Location	Recurring Losses - By Event 10 Year	50 Year	100 Year	500 Year
Marlborough	$ 71,000	$ 203,000	$ 271,000	$ 398,200
Keene	107,000	843,000	3,797,000	7,962,000
Winchester	5,000	111,000	360,000	1,154,000
Total	$183,000	$1,157,000	$4,428,000	$9,514,000

Annual Losses

The purpose of estimating annual losses is to measure the severity of potential flooding on an "expected annual" basis in each damage center. Annual losses are the integration and summation of two sets of data at each damage location. Recurring losses for each flood elevation (event) are multiplied by the annual percent chance of occurrence that each specific flood elevation (event) will be reached. The effectiveness of each alternative flood reduction plan is measured by the extent to which it reduces annual losses. Annual losses in the 3 basin towns are found in Table B-2.

Table B-2

Annual Losses

Location	Annual Losses
Marlborough	$ 24,000
Keene	109,000
Winchester	12,000
Total	$145,000

Specific Study Areas and Sub Areas

In the analysis of the specific study areas, individual damage centers in each town were examined in terms of floodplain activities, floodplain characteristics, recurring losses and annual losses. Benefits were estimated for each plan of improvement and a benefit cost ratio and net benefits were calculated. The towns of Marlborough and Winchester and the city of Keene were examined.

(1) MARLBOROUGH,N.H.

Three areas of Marlborough were identified as areas with potential for flood losses under the existing without project condition. The areas are (i) the Route 101 bridge over the Minnewawa Brook, (ii) the commercial area just downstream of the bridge and (iii) the Water St. area.

(i) Route 101 Bridge Area - There are 2 commercial activities and 5 residences in this area. Flooding is not significant in this area as recurring losses are $37,000 for the 100 year event and $90,500 for the 500 year event. Annual losses are only $1,800. No improvement plans were formulated for this area.

(ii) Commercial Area - (750 feet downstream of Rt. 101 bridge) - This area contains 4 commercial activities housed in 3 structures. A grocery store and bank share one structure, while a bookstore and florist/nursery occupy the other two structures. The first floors of the structures are at ground level and lie 1 to 2 feet below the elevation of the 100 year event. Recurring losses and annual losses are as follows:

	Recurring Losses - By Event				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Rt. 101	$31,400	$65,500	$97,500	$150,000	$11,400

One alternative structural plan of improvement, channel widening, was formulated for this area. A nonstructural dry floodproofing plan to seal openings was also formulated.

	Annual Losses		Annual
Plan	Natural (w/o plan)	w/Improvement	Benefits
Structural Plan - Channel Widening	$11,400	$600	$10,800
Nonstructural Plan - Dry Floodproofing	$11,400	$5,700	$5,700

The economic justification of each plan is determined in the following summary ta

	Improvement Plans: Channel Widening	Improvement Plans: Dry Flood-proofing
Annual Benefits	$10,800	$5,700
Annual Costs	8,100	6,800
Benefit/Cost Ratio	1.33 to 1	0.86 to 1
Net Benefits	$2,800	-

(iii) Water St. Area - This third area under consideration in Marlborough is occupied by 5 residences, 4 commercial structures and a playground/ball field. All but 2 of the structures have first floor elevations below the 100 year which results in the following array of recurring losses and annual losses.

	Recurring Losses - By Event				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Water St.	$38,000	$117,500	$136,800	$157,700	$11,200

One structural improvement plan was formulated which involves modifying the channel, removing a small dam and providing stone slope protection. The nonstructural dry floodproofing plan would provide impermeable seals around structural openings to prevent intrusion of floodwater.

	Annual Losses		Annual
Plan	Natural w/o Plan	w/Improvement	Benefits
Channel Mod	$11,200	$2,500	$8,700
Dry Floodproofing	11,200	8,400	2,800

The comparison of annual costs and benefits indicates that neither plan is economically justified.

	Improvement Plans: Channel Modification	Improvement Plans: Dry Floodproofing
Annual Benefits	$ 8,700	$2,800
Annual Costs	15,200	5,900
Benefit/Cost Ratio	0.57 to 1	0.47 to 1
Net Benefits	-	-

(2) KEENE, N.H.

Five areas of the city of Keene were investigated as areas of potential flooding under the existing without project condition. The areas are: (i) the area containing the 2 shopping malls and Keene State College, (ii) the Ash Swamp Brook area, (iii) Martel Court, (iv) Tanglewood Estates and (v) the West St. area.

(i) Malls/Keene State College Area - This area is characterized by a mix of residential, commercial and public (college) buildings. There are 130 residential structures, 57 commercial (retail sales) structures and 21 buildings on the Keene State College campus. Recurring losses do not reach the significant level until the occurrence of the 100 year event as shown in the following table.

	Recurring Losses - By Event			
	10 Year	50 Year	100 Year	500 Year
Malls/Keene State	$1,500	$317,900	$2,767,800	$6,174,200

Because significant flood losses are incurred at the rarer events, expected annual losses amount to $59,100. Due to this low level of annual losses and the somewhat large geographical area to be protected structural alternatives were not formulated.

(ii) Ash Swamp Brook Area - The Ash Swamp Brook floodplain in Keene is occupied by 70 structures, which are divided evenly between commercial (retail sales) and residential activities. Flooding does occur in this area but not at levels which result in significant losses as the recurring losses table indicates.

	Recurring Losses - By Event			
	10 Year	50 Year	100 Year	500 Year
Ash Swamp Brook	$600	$54,300	$227,300	$477,000

With annual losses of only $5,900, structural plans were not formulated.

(iii) Martell Court - Located near the confluence of the Ashuelot River, Branch River and Beaver Brook, Martel Court is the site of 6 commercial structures and 3 residences. The ground elevation in this area is at 470 feet NGVD which corresponds to the elevation of the 50 year flood event. Most of the buildings are sited and used in recognition of their location near the confluence and potential flood levels. The area is flat and the 100 and 500 year flood elevations are only 1.3 and 2.7 feet respectively greater than the 50 year event. Because of these factors, annual losses are only $1,000. An improvement plan consisting of I-walls and earthen dikes was evaluated, but was not justified due to the low level of annual losses and resulting benefits. A nonstructural dry floodproofing plan to seal openings in structures was also not economically justified.

	Improved Plans	
	Dikes and Walls	Dry Floodproofing
Annual Benefits	$ 1,000	$ 800
Annual Costs	$144,500	$4,100
Benefit/Cost Ratio	0.01 to 1	0.2 to 1
Net Benefits	-	-

(iv) Tanglewood Estates - This area is a permanent residential trailer park that lies within the Ashuelot floodplain in northern Keene. There are 60 trailers at the site, 45 of which have their first floors below the 100 year flood elevation. Recurring losses are as follows:

	Recurring Losses - By Event			
	10 Year	50 Year	100 Year	500 Year
Tanglewood Estates	$105,000	$456,000	$772,200	$1,263,000

Annual losses for the area were estimated to be $42,400. One structural improvement plan, an earthen dike, and two nonstructural plans, raising structures and dry floodproofing, were formulated for this area. None of the plans was economically justified.

	Improvement Plans		
	Dike	Raising Structures	Dry Floodproofing
Annual Benefits	$41,000	$ 15,000	$10,600
Annual Costs	$66,200	$115,000	$25,000
Benefit/Cost Ratio	0.62 to 1	0.13 to 1	0.42 to 1
Net Benefits	-	-	-

(v) West St. to Winchester St. - A section of West St., from Island St. to the railroad embankment experienced flooding during the 1987 event. It was learned that floating debris caught in a bridge opening was the cause. Annual losses were estimated for the car wash and storage buildings in the area and amounted to less than $1,000 annually. No improvement plans were formulated.

(3) WINCHESTER, N.H.

Three areas in the town of Winchester were investigated as areas of potential flooding under the existing without project condition. The areas are: (i) Rt. 10 - vicinity of Lawrence Leathers Inc., (ii) downtown Winchester and (iii) Kulick's Country Mall.

(i) Route 10 - This area contains 6 houses along the riverbank on Route 10 and Lawrence Leathers Inc., an industrial property, which is currently not in operation. Potential flood losses are low in this area with 100 year recurring losses of $23,500 and annual losses of $1,000. No improvement plans were formulated.

(ii) Downtown Winchester - This area contains 29 structures, 9 of which are located on Hildreth St. and the remainder on Main St. There are 12 residences, 12 commercial structures and 5 public buildings. Only one structure has a first floor elevation below the 100 year flood level; that structure is the Police/Fire Station which is on a concrete slab at ground level. As expected, total recurring losses are not high in this area.

	Recurring Losses - By Event			
	10 Year	50 Year	100 Year	500 Year
Downtown	$1,200	$28,500	$59,600	$209,300

Annual losses, reflective of flooding from less frequent events, amount to $2,400. An improvement plan consisting of channel improvements was formulated. It will be evaluated under (iii) below as the plan also affects Kulick's Mall.

(iii) Kulick's Mall - The mall is a single, one-story, cinder block structure which houses 10 separate retail activities. A car wash and gasoline station are located in the parking lot. The mall is located near Mirey Brook and its confluence with the Ashuelot River. The ground and first floor elevation of the mall, which is on a slab, corresponds to the flood elevation of the 33 year or 3 percent chance event.

	Recurring Losses - By Event			
	10 Year	50 Year	100 Year	500 Year
Kulick's Mall	$3,600	$78,000	$276,700	$785,000

Annual losses for the mall and the 2 parking lot properties are estimated to be $8,400. The structural plan formulated for the Ashuelot River in Winchester is modifications to the channel. This plan will affect river stages in both the downtown area and at the confluence with Mirey Brook near Kulick's Mall. Also a nonstructural plan of dry floodproofing the mall by sealing structural openings was formulated. Neither plan is justified.

	Improvement Plans	
	Channel Modifications	Dry Floodproofing
Annual Benefits	$5,100	$4,200
Downtown	(1,000)	-
Kulick's Mall	(3,900)	(4,200)
Annual Costs	605,000	13,800
Benefit/Cost Ratio	0.01 to 1	0.30 to 1
Net Benefits	-	-